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Kuroyanagi et al.

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(45) **Date of Patent: Nov. 10, 2015**

(54) **HIGH PRESSURE PUMP HAVING UNITARY DISCHARGE AND RELIEF VALVE**

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(73) Assignee: **DENSO CORPORATION**, Kariya (JP)

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(30) **Foreign Application Priority Data**

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Aug. 31, 2011 (JP) 2011-188386
Aug. 31, 2011 (JP) 2011-188440

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F04B 53/00 (2006.01)
F04C 14/26 (2006.01)
F16K 17/04 (2006.01)
F04B 49/24 (2006.01)
F04B 49/035 (2006.01)

(52) **U.S. Cl.**

CPC ***F04B 49/24*** (2013.01); ***F04B 49/035*** (2013.01); ***F04B 53/00*** (2013.01); ***F04C 14/26*** (2013.01); ***F16K 17/048*** (2013.01)

(58) **Field of Classification Search**

CPC F04B 49/24; F04B 53/109; F04B 49/035; F04C 14/26; F16K 17/048; F16K 17/04; F16K 17/20; F02M 59/46
USPC 417/440, 507, 307, 308, 296, 567, 568, 417/297; 137/493, 493.9; 123/506
See application file for complete search history.

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(57) **ABSTRACT**

A valve body is provided with a discharge relief portion. A relief valve outlet is formed in an end face thereof on a central axis of the valve body. Discharge valve inlets are point-symmetrically formed with respect to the central axis. A discharge valve outlet is formed in another end face thereof and relief valve inlets are point-symmetrically formed with respect to the central axis. A discharge valve outlet and the discharge valve inlets communicate with each other. A flow of fuel from a pressurization chamber to a fuel discharge port is restricted by a discharge valve member capable of closing the discharge valve outlet. The relief valve outlet and the relief valve inlets communicate with each other. A flow of fuel from the fuel discharge port to the pressurization chamber is restricted by a relief valve member capable of closing the relief valve outlet.

7 Claims, 13 Drawing Sheets

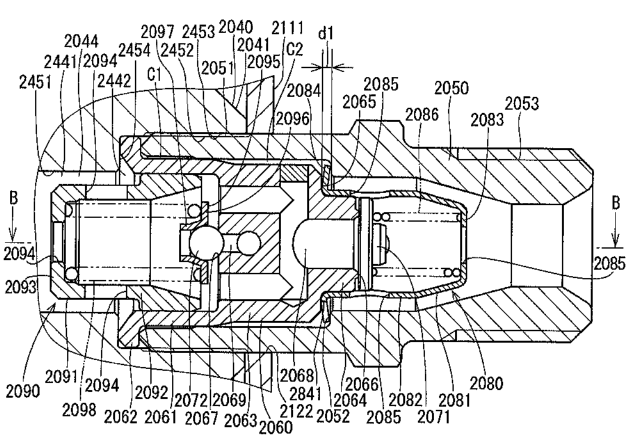

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FIG. 1

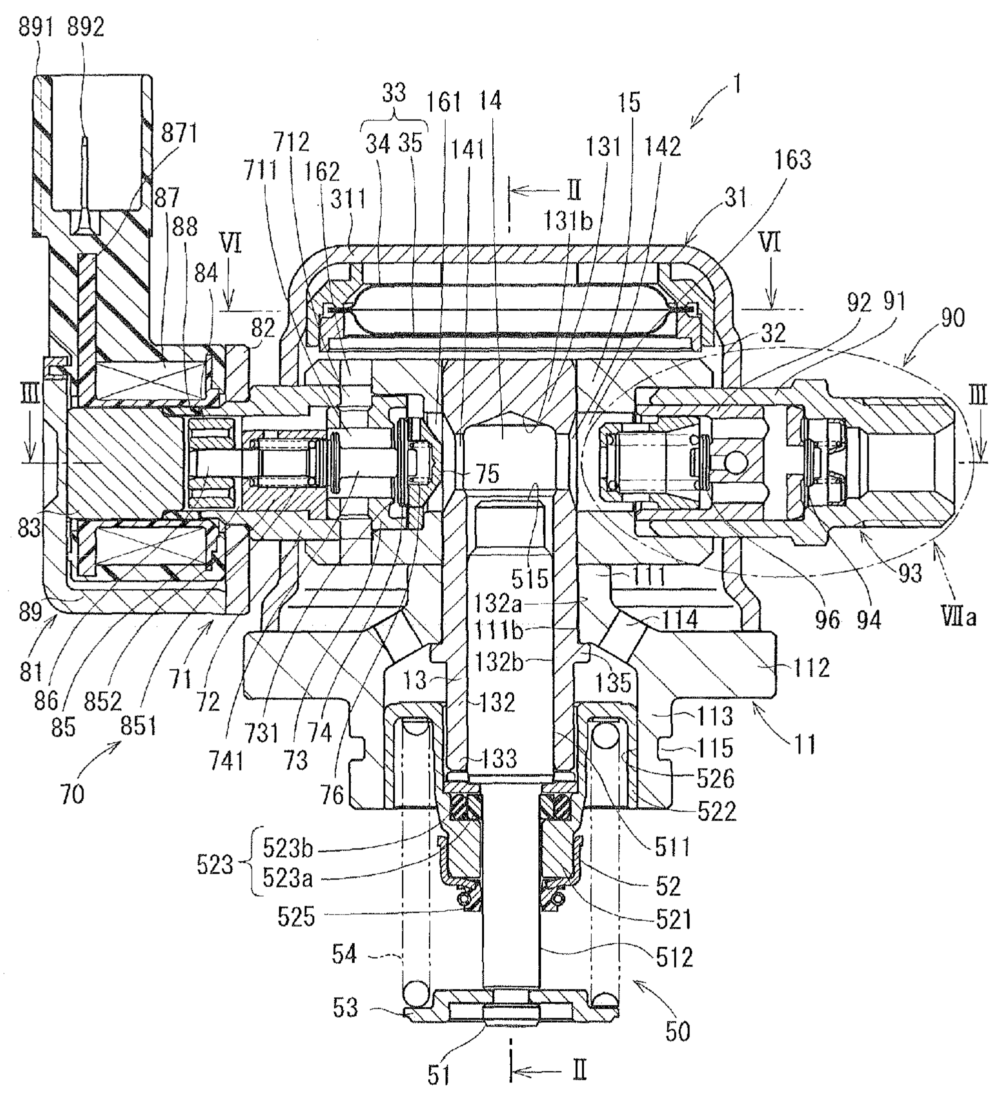
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FIG. 2

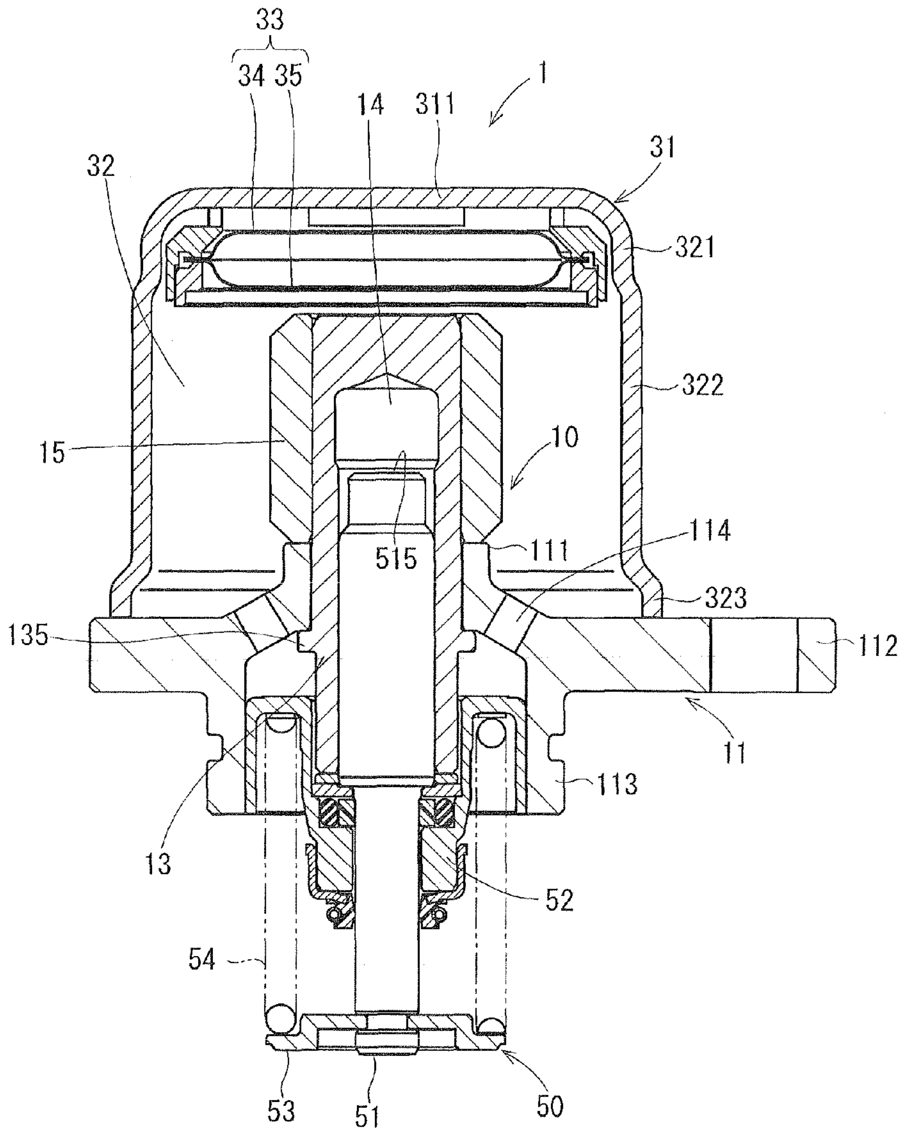
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FIG. 3

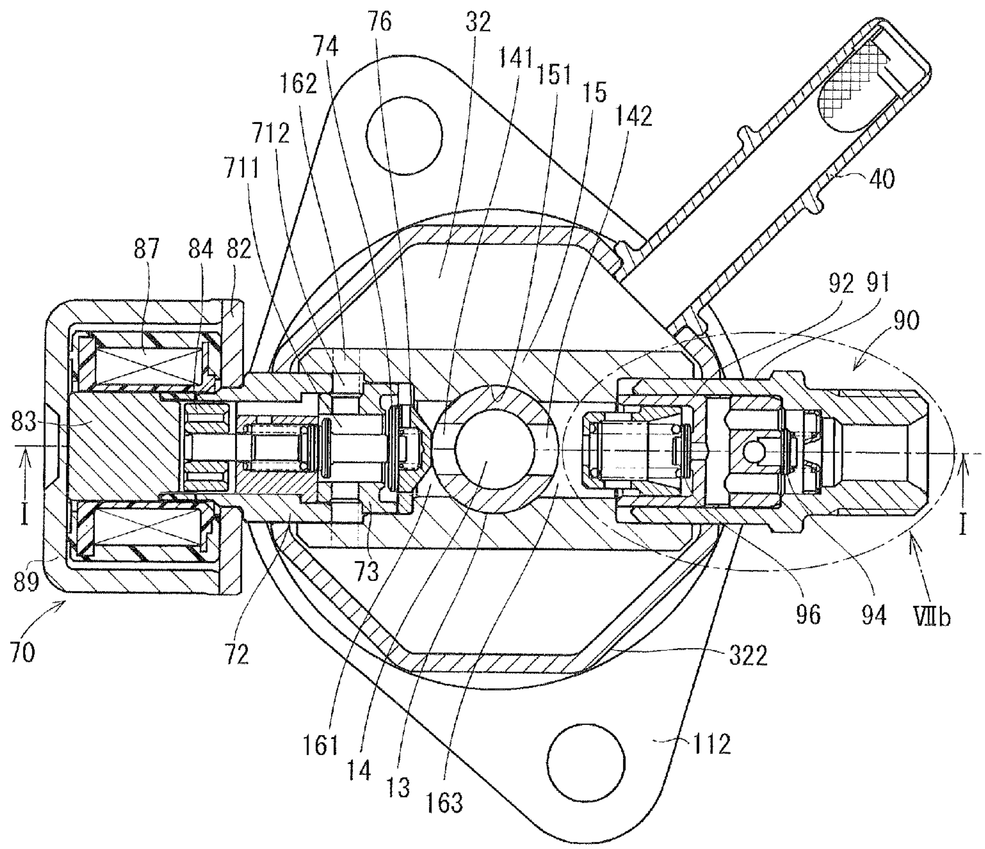

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FIG. 4

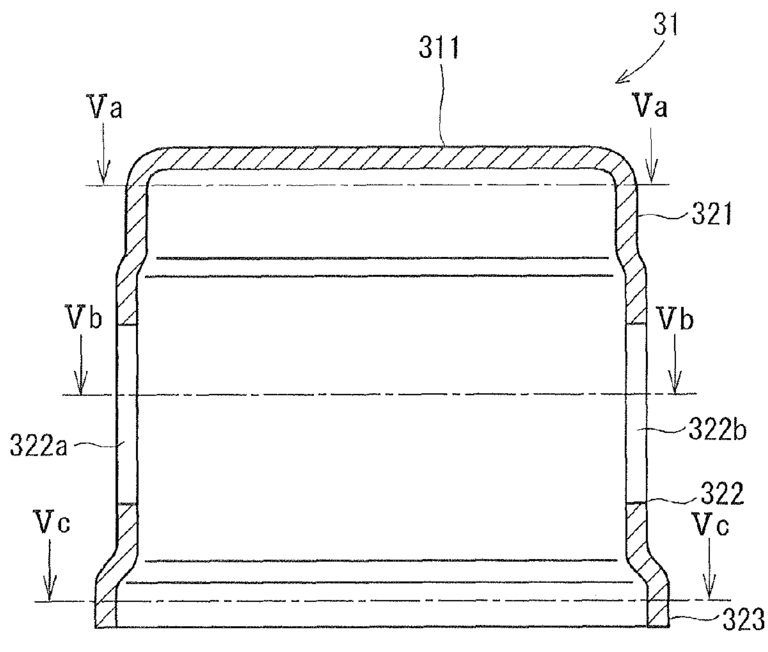

FIG. 5A

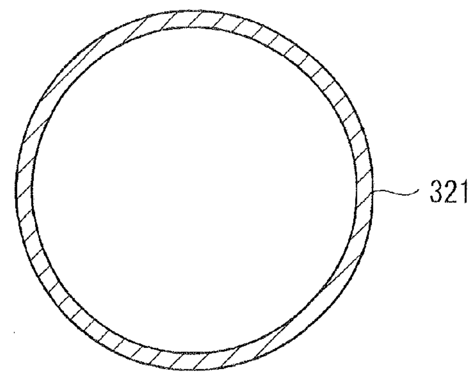

FIG. 5B

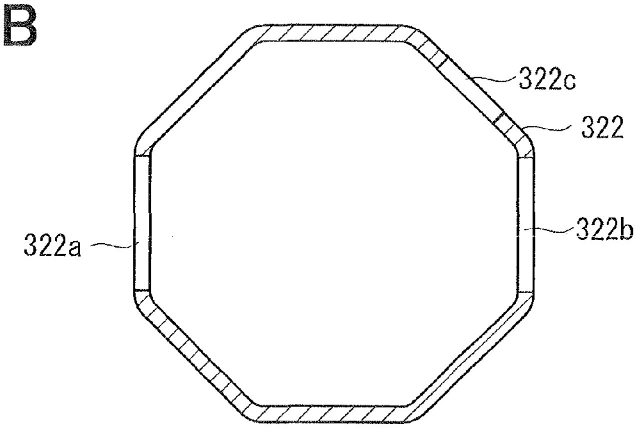

FIG. 5C

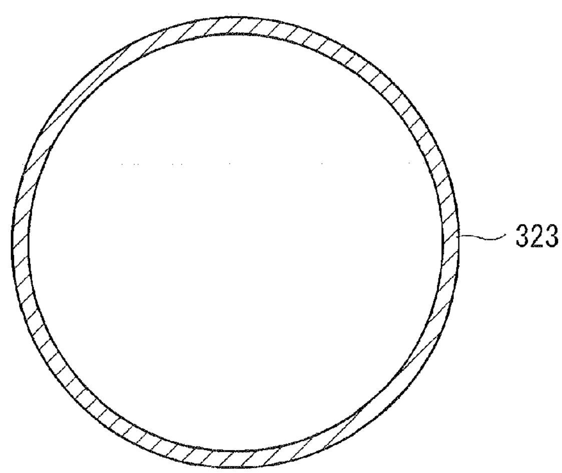

FIG. 6

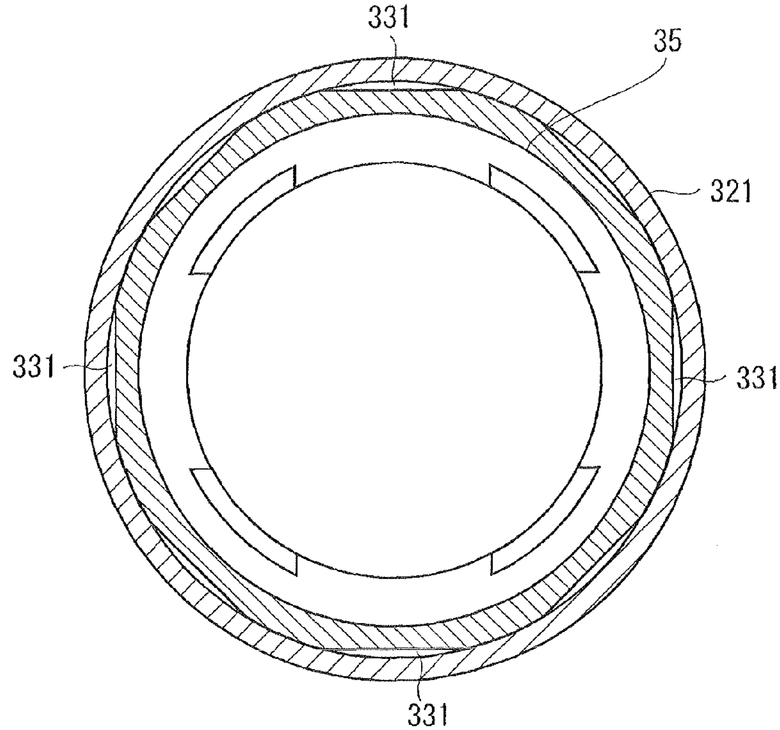

FIG. 7A

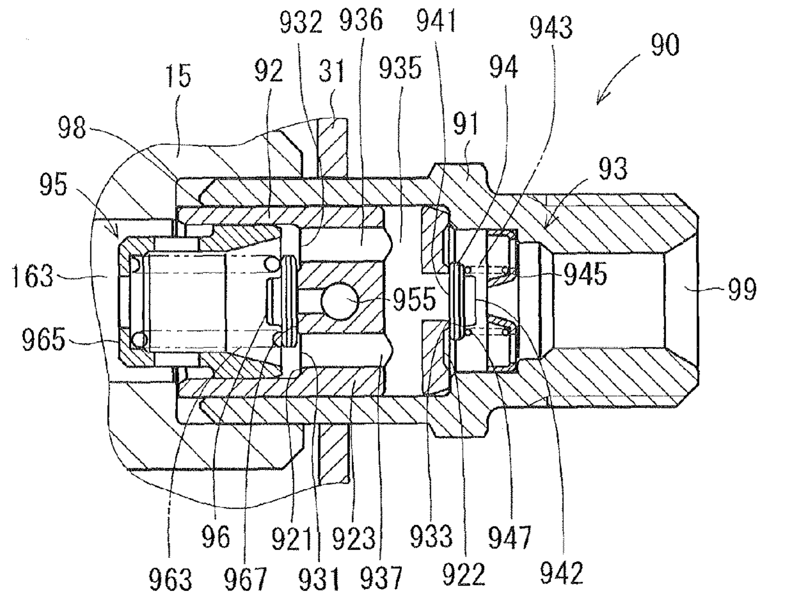
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FIG. 7B

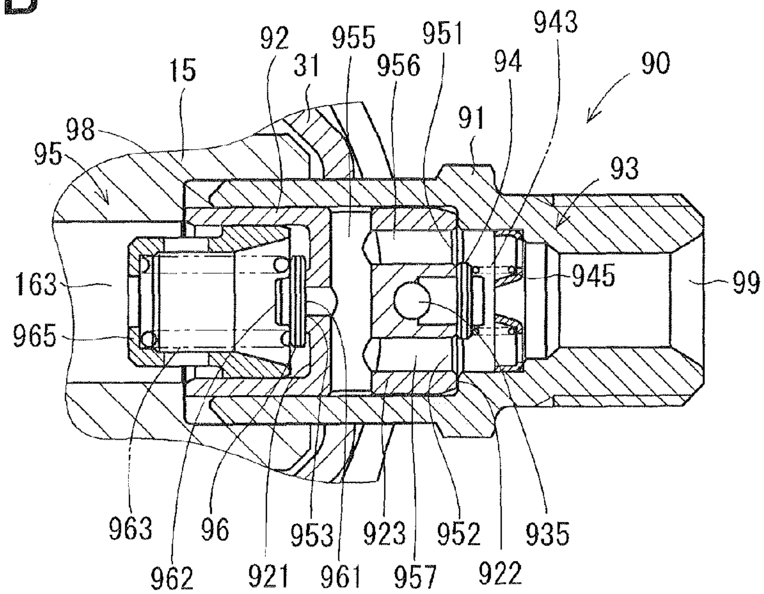
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FIG. 8

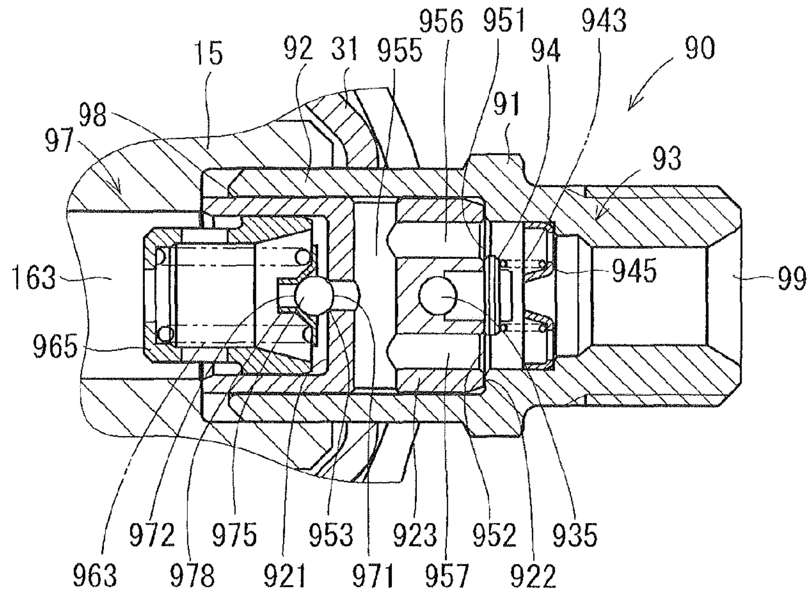
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FIG. 9

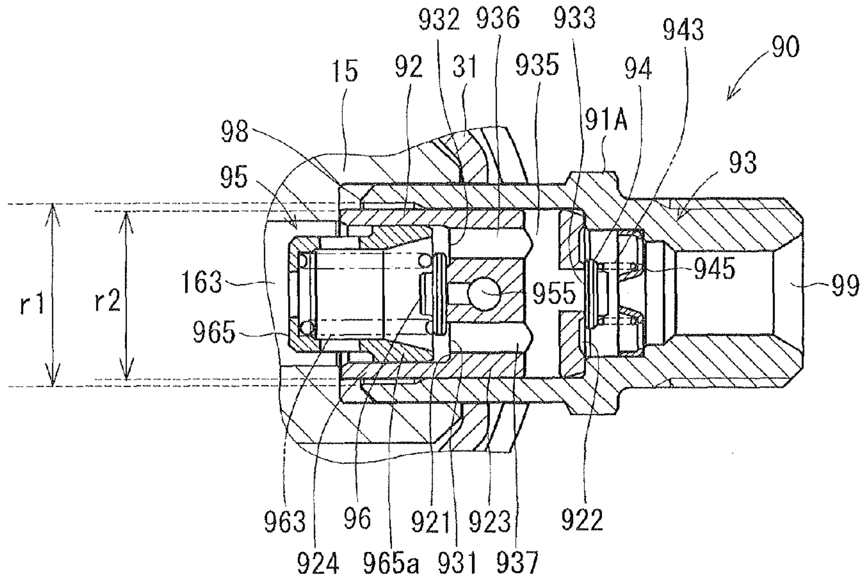
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FIG. 10

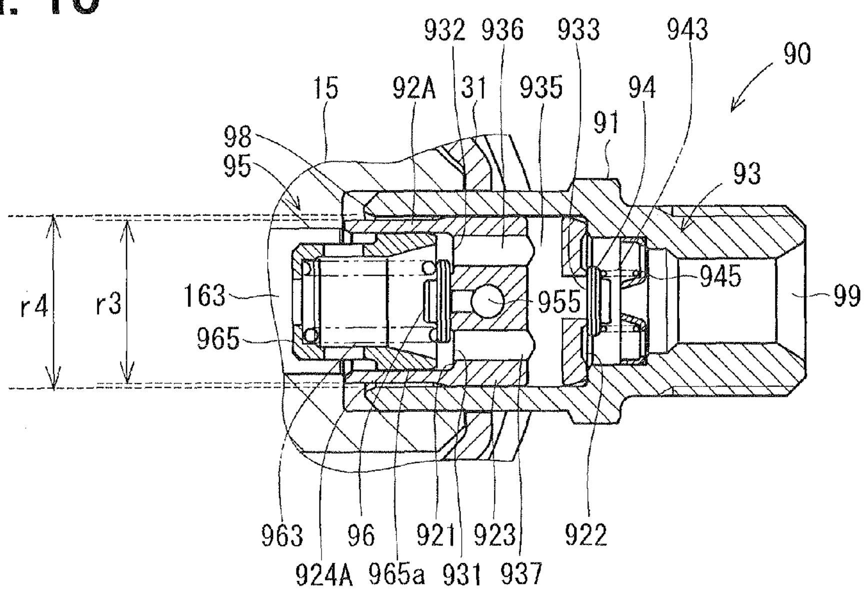
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FIG. 11

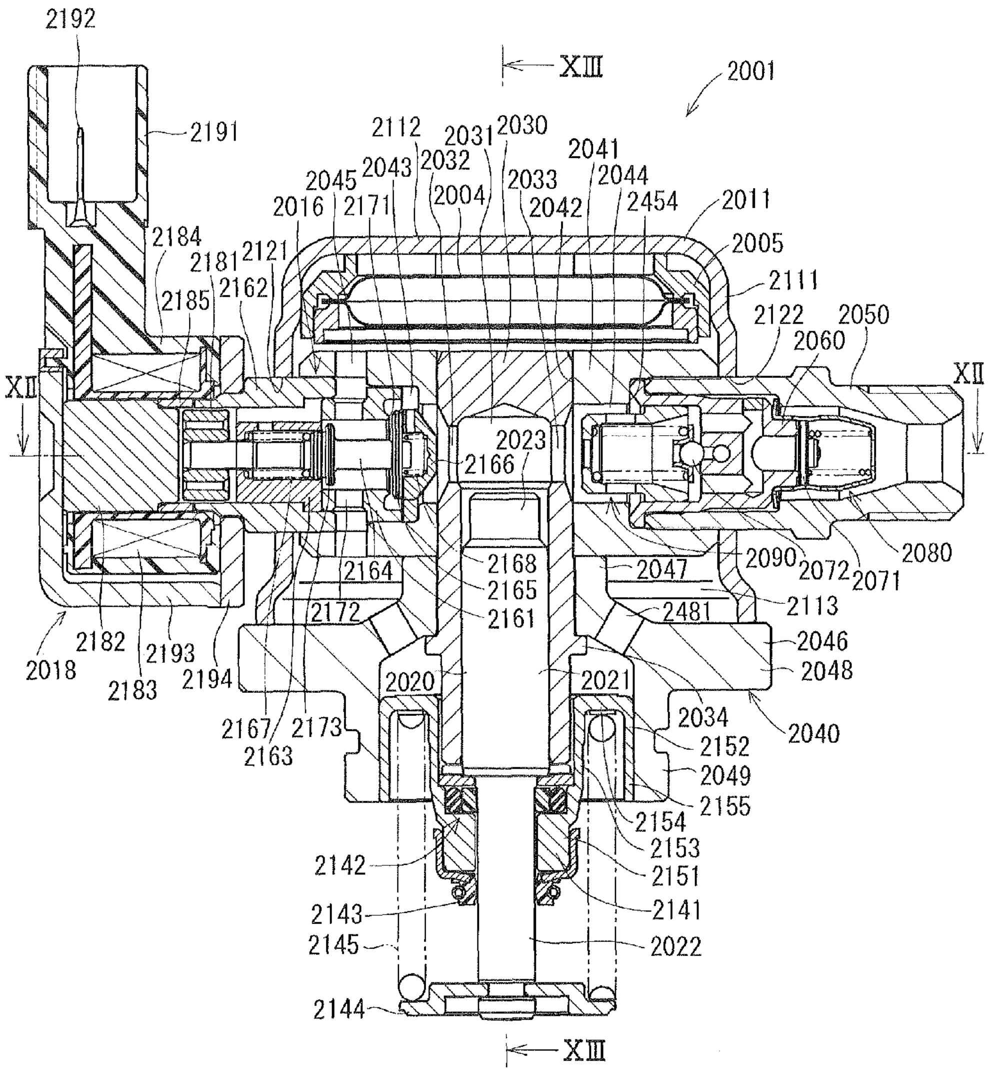
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FIG. 12

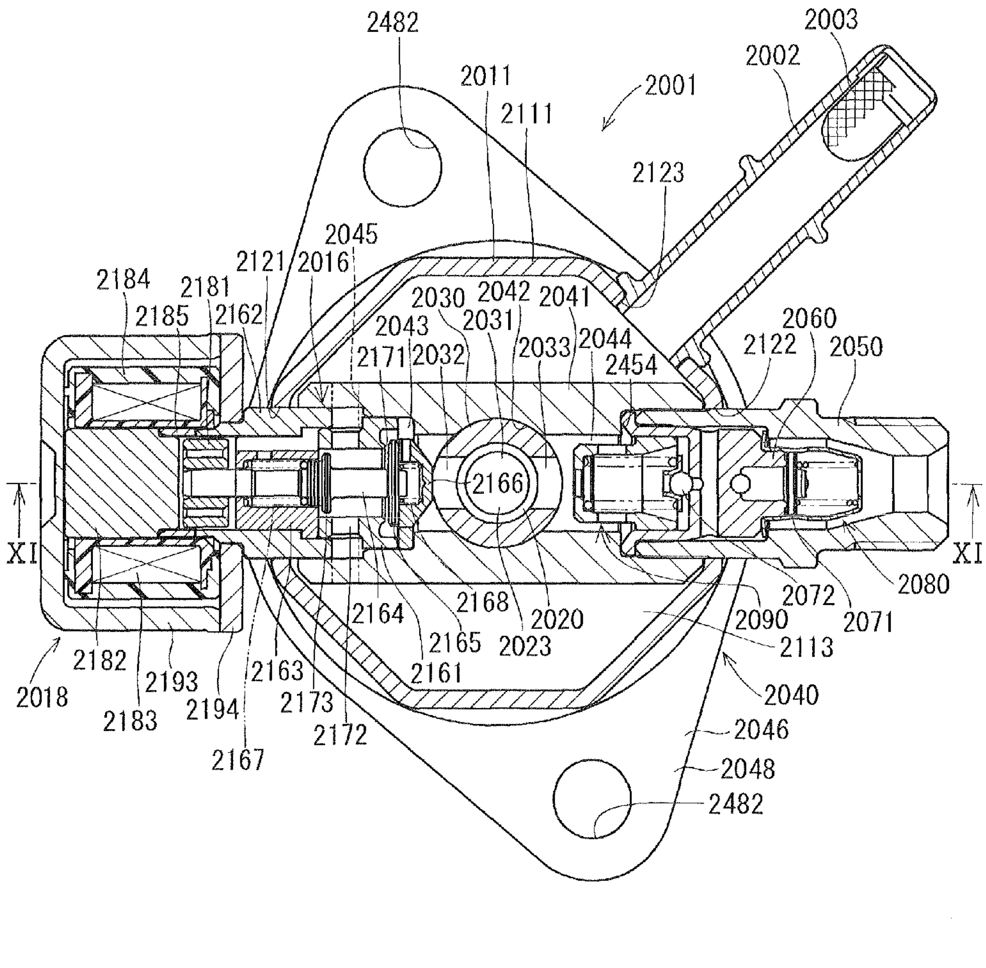
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FIG. 13

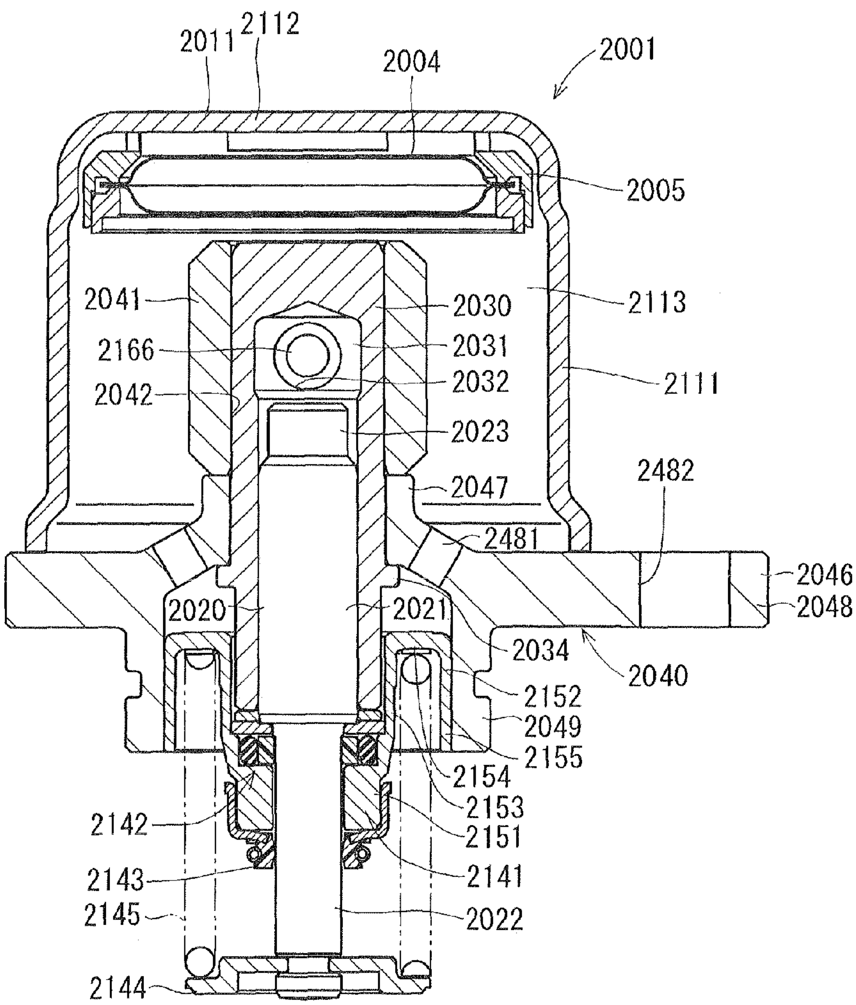
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FIG. 14A

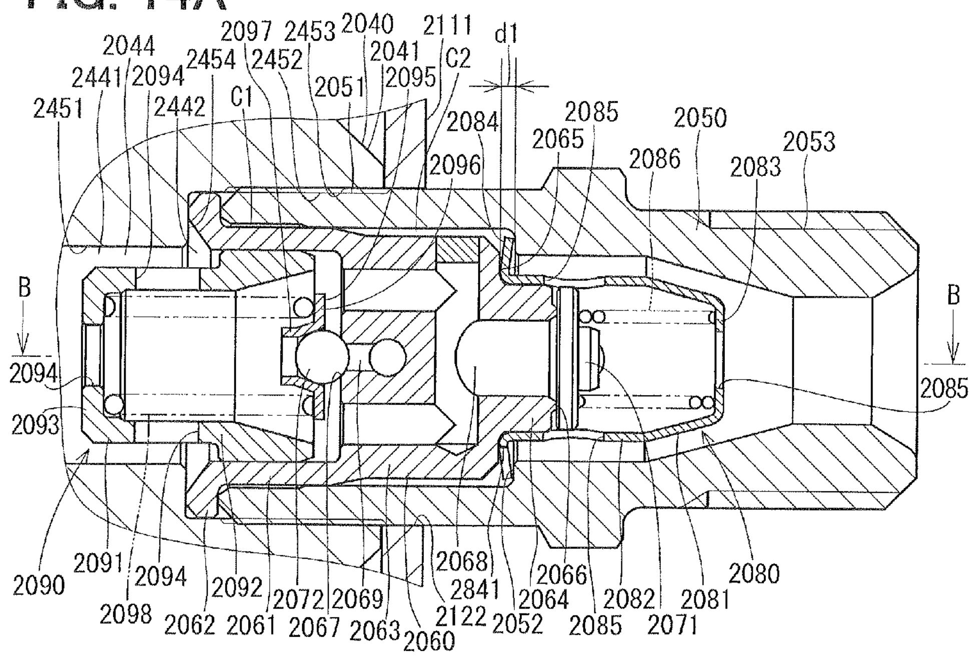
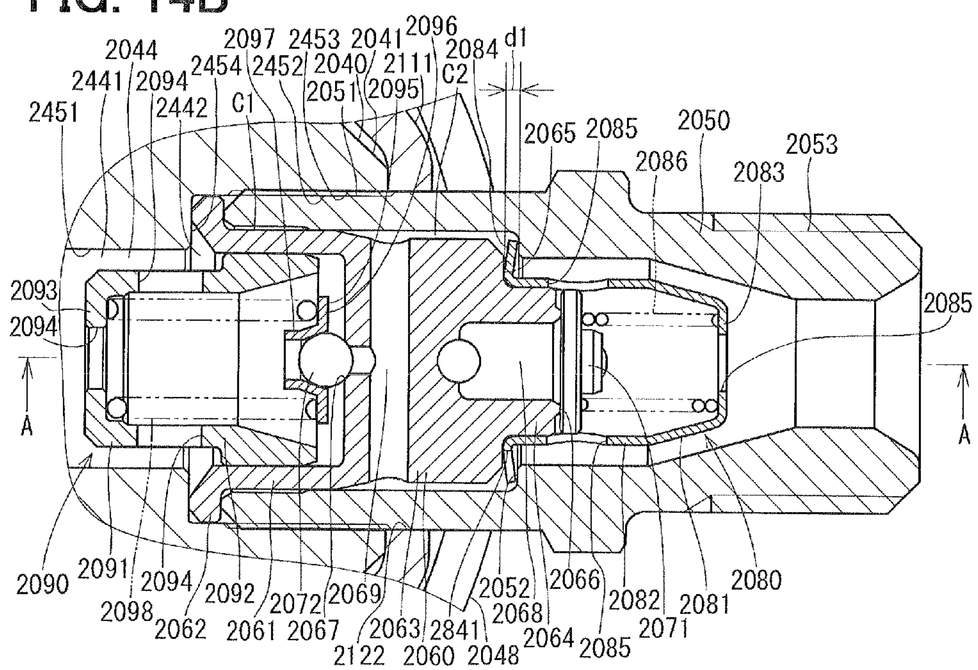


FIG. 14B



HIGH PRESSURE PUMP HAVING UNITARY DISCHARGE AND RELIEF VALVE

CROSS-REFERENCE TO RELATED APPLICATION

This application is based on Japanese Patent Applications No. 2011-77655 filed on Mar. 31, 2011, No. 2011-188386 filed on Aug. 31, 2011 and No. 2011-188440 filed on Aug. 31, 2011, the disclosures of which are incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to a high-pressure pump used for an internal combustion engine.

BACKGROUND

In a fuel supply apparatus for supplying a fuel to an internal combustion engine, a high-pressure fuel supplied from a high-pressure pump is accumulated in a fuel accumulator. The accumulated high-pressure fuel is injected into a combustion chamber of the engine through a fuel injector. A high-pressure pump is equipped with a relief valve. When the fuel pressure in the fuel accumulator is excessively raised beyond an allowable value due to a malfunction in a suction valve or a discharge valve of the high-pressure valve, the relief valve is opened to relieve the high-pressure fuel into a return passage.

In a high-pressure pump shown in JP-2440-138062A, a discharge passage and a relief passage are arranged in parallel with each other. The discharge passage is formed for pressure-feeding the fuel in a pressurization chamber to a discharge port through a discharge valve. The relief passage is formed for returning the fuel of excessive pressure in a fuel accumulator from the discharge port to the pressurization chamber through a relief valve. When the high-pressure pump discharges the fuel, the fuel pressure in the pressurization chamber acts to open the discharge valve, and simultaneously acts in such a direction that the relief valve is abutted against a seat portion. Therefore, even when the fuel pressure in the pressurization chamber exceeds a relief valve opening pressure at the time of discharge, the relief valve is not opened. As a result, a part of discharged fuel is prevented from flowing out of the relief valve and the accuracy of metering is ensured.

In the high-pressure pump shown in JP-2004-138062A, a chamber for accommodating the discharge valve and a chamber for accommodating the relief valve are separately independently formed in a housing, whereby a lot of high-pressure seals are necessary therebetween.

In the high-pressure pump shown in U.S. Pat. No. 7,401,593B2, a chamber for accommodating a discharge valve and a chamber for accommodating a relief valve are separately formed in a bottom of one large hole (chamber). Then, a discharge connector is joined to the opening of the large hole. The number of points where a high-pressure seal is necessary is thereby reduced.

In the high-pressure pump shown in JP-2010-174903A, a fuel is returned to a low-pressure area, not to a pressurization chamber, when a relief valve is opened. When the fuel is discharged, the relief passage from the discharge port to the relief valve is closed in conjunction with a lifting of a discharge valve. As a result, when the fuel pressure in a pressurization chamber exceeds a relief valve opening pressure, it can be avoided that the relief valve is opened and a part of discharged fuel flows out, so that an accuracy of metering is ensured.

In the high-pressure pump disclosed in JP-2004-138062A, a cylindrical member forming the valve seat of the discharge valve is press-inserted into an inner wall of the housing of the high-pressure pump. For this reason, a force from the inner wall of the housing is exerted on the cylindrical member forming the valve seat of the discharge valve in an inward radial direction.

In the high-pressure pump disclosed in U.S. Pat. No. 7,401,593B2, a closed-end cylindrical holder is welded or calked on the outer wall of a member forming the valve seat of the discharge valve. The holder holds a biasing member for biasing a discharge valve member in a valve-close direction. For this reason, a force from the holder is exerted on the member forming the valve seat of the discharge valve in the inward radial direction due to welding or calking.

In the high-pressure pumps disclosed in JP-2004-138062A and U.S. Pat. No. 7,401,593B2, a discharge passage and a relief passage are arranged in parallel with each other and both of them communicate with a pressurization chamber. For this reason, in addition to the fuel in the pressurization chamber, the fuel in the discharge passage and the relief passage is simultaneously pressurized during a pressurization stroke. That is, in the high-pressure pumps in the Patent Documents 1 and 2, "dead volume" other than the pressurization chamber is increased, which deteriorates a discharging efficiency of a high-pressure pump.

In the high-pressure pump shown in JP-2010-174903A, the dead volume is not increased. However, the configuration of a discharge valve is complicated and high machining accuracy is required, which increases its manufacturing cost. A fuel pressure pulsation in the high-pressure pipe from the high-pressure pump to the fuel accumulator has great influence on the lift of the discharge valve. The fuel pressure pulsation is varied depending on a bend position, a bend angle, and the like in high-pressure pipe as well as the engine speed and the discharge rate of a pump. It is necessary to tune various elements of a discharge valve for individual engines. This increases a manufacturing cost.

In the high-pressure pumps shown in JP-2004-138062A, U.S. Pat. No. 7,401,593B2, and JP-2010-174903A, a discharge valve and a relief valve are provided in different passages and it is necessary to form chambers accommodating the both valves. This increases a physical size of the housing and its manufacturing cost.

When a force from the inner wall of the housing is exerted on a member forming the valve seat of a discharge valve in the inward radial direction, there is a possibility that the valve seat portion is deformed. When the valve seat portion is deformed, the tight abutment between the valve seat and a discharge valve member is prevented and there is a possibility that discharge pressure is reduced or destabilized.

In the high-pressure pump shown in JP-2004-138062A, a member forming the valve seat of the discharge valve is just press-inserted into the inner wall of the housing. Therefore, it is likely that the member may get out of the inner wall of the housing due to an internal pressure established when the high-pressure pump is in operation.

Also, the high-pressure pump in JP-2004-198062A, is provided with the relief valve for returning the fuel to the pressurization chamber of the high-pressure pump when the fuel pressure becomes greater than a predetermined value. A cylindrical member forming the valve seat of this relief valve is press-inserted into the inner wall of the housing of the high-pressure pump. Therefore, the same problem as mentioned above may occur with respect to the member forming the valve seat of the relief valve.

When a force from a holder is exerted on the member forming the valve seat of the discharge valve in the inward radial direction, there is a possibility that the valve seat portion is deformed. When the valve seat portion is deformed, the tight abutment between the valve seat and a discharge valve member is prevented and there is a possibility that discharge pressure is reduced or destabilized.

Also, the high-pressure pump in U.S. Pat. No. 7,104,593B2 is provided with the relief valve for returning fuel to the pressurization chamber of the high-pressure pump when the pressure of fuel becomes greater than a predetermined pressure. A closed-end cylindrical holder that holds a biasing member for biasing a relief valve member in a valve-close direction is welded or calked on the outer wall of a member forming the valve seat of this relief valve. Therefore, the same problem as mentioned above may occur with respect to the member forming the valve seat of the relief valve.

SUMMARY

It is an object of the present disclosure to provide a high-pressure pump in which a discharge valve and a relief valve are simplified in their configuration and a discharging efficiency is enhanced.

It is another object of the present disclosure to provide a high-pressure pump in which it is possible to suppress a deformation in a member forming a valve seat.

A high-pressure pump includes a plunger, a cylinder and a housing. The cylinder accommodates the plunger so that it can be reciprocatively moved in the axial direction. The cylinder defines a pressurization chamber in cooperation with the outer wall of the plunger. The housing accommodates the cylinder and defines a fuel passage for discharging the fuel pressurized in the pressurization chamber.

A valve body connected to the housing includes a discharge valve inlet and a relief valve outlet which communicate with the fuel passage, a discharge valve outlet, a relief valve inlet, a discharge valve passage fluidly connecting the discharge valve inlet and the discharge valve outlet, and a relief valve passage communicating with the relief valve inlet and the relief valve outlet.

The relief valve passage is fluidly disconnected with the discharge valve passage. A discharge valve seat is formed on an end face of the valve body opposite to the pressurization chamber. A relief valve seat is formed on another end face of the valve body confronting the pressurization chamber. The discharge valve member is provided in such a manner as to abut against the discharge valve seat. The relief valve member is provided in series with the discharge valve member in an axial direction of the valve body so as to abut against the relief valve seat. A discharge valve biasing portion biases the discharge valve member in a direction in which the discharge valve member is seated on the discharge valve seat. A relief valve biasing portion biases the relief valve member in a direction in which the relief valve member is seated on the relief valve seat.

A first pressure force is exerted on the discharge valve member confronting the pressurization chamber by the fuel pressure in the pressurization chamber.

A second pressure force is exerted on the discharge valve member opposite to the pressurization chamber. When the first pressure force is lower than or equal to a discharge valve acting force that is a resultant force of the second pressure force and the biasing force of the discharge valve biasing portion, the discharge valve member is seated on the discharge valve seat to close the discharge valve outlet.

As a result, a fuel flow from the pressurization chamber is interrupted. When the first pressure force is larger than the discharge valve acting force, the discharge valve member is unseated from the discharge valve seat to open the discharge valve outlet. As a result, the fuel flow from the pressurization chamber is permitted.

A third pressure force is exerted on the relief valve member opposed to the pressurization chamber. A fourth pressure force is exerted on the relief valve member confronting to the pressurization chamber by the fuel pressure in the pressurization chamber side.

When the third pressure force is lower than or equal to the relief valve acting force that is a resultant force of the fourth pressure force and the biasing force of the relief valve biasing portion, the relief valve member is seated on the relief valve seat to close the relief valve outlet. As a result, the fuel flow toward the pressurization chamber is interrupted.

When the third pressure force is larger than the relief valve acting force, the relief valve member is unseated from the relief valve seat to open the relief valve outlet. As a result, the fuel flow toward the pressurization chamber is permitted.

The discharge valve seat and the relief valve seat are provided in the one valve body so that they are opposed to each other. Therefore, the discharge valve and the relief valve can be arranged in series in the direction of the axis of the valve body. Two different valves are accommodated in one passage. Therefore, the configuration can be simplified as compared with conventional technologies in which a discharge valve and a relief valve are arranged in different passages. The physical sizes of the discharge valve and the relief valve can be reduced. In addition, the manufacturing cost can be reduced.

The discharge valve passage for the discharge valve and the relief valve passage for the relief valve are formed in a single valve body. This makes it possible to reduce the volume required for passages used for the two valves. Therefore, a dead volume that is a pressurized volumetric capacity other than the pressurization chamber can be reduced. The discharging efficiency of the high-pressure pump can be enhanced.

The discharge valve passage and the relief valve passage are formed in a single valve body, and the discharge valve member, the relief valve member, the discharge valve energizing portion and the relief valve energizing portion are arranged therein. The discharge portion of the high-pressure pump is configured as a sub-assembly. With this configuration, advantages (i) to (iii) described below are obtained when the high-pressure pump is manufactured.

(i) The discharge relief valve unit can be produced in a sub-assembly line which is independent from a main assembly line for the high-pressure pump, whereby a takt time can be shortened.

(ii) When inspecting the relief valve opening pressure, a discharge relief valve unit has to be set in inspection equipment. Since the discharge relief valve unit is relatively small in its size, the inspection equipment can be also reduced in its size.

(iii) When the relief valve opening pressure is not within the predetermined range due to an inspecting equipment, it is inevitable to discard the work piece as a defective. For this reason, with the configuration in which the valve opening pressure of the relief valve is adjusted as for the entire housing, any defective must be discarded together with the housing. Meanwhile, when the discharge relief valve unit is configured as a sub-assembly, this defective discharge relief valve unit only has to be discarded and the loss cost arising from discard can be significantly reduced.

According to another aspect of the invention, the high-pressure pump includes a plunger, a cylinder, a housing, a cylindrical member, a valve body, a discharge valve member, and a discharge valve biasing portion.

The cylinder includes: a plunger accommodating hole for reciprocatively accommodating the plunger; a pressurization chamber formed by its inner wall and the outer wall of the plunger; a suction port for suctioning a fluid into a pressurization chamber; and a discharge port for discharging the fluid pressurized in the pressurization chamber.

The housing includes: a first inner wall surface forming a first discharge passage communicating with the discharge port; a second inner wall surface forming a second discharge passage communicating with the first discharge passage; and a stepped surface formed between the first inner wall surface and the second inner wall surface. An inner diameter of the second inner wall is larger than that of the first inner wall surface. The cylindrical member is so provided that one end thereof is positioned inside of the second inner wall surface of the housing.

The valve body includes: a cylindrical portion accommodated inside of the cylindrical member; a flange portion extended from the cylindrical portion confronting the pressurization chamber side in an outward radial direction and being sandwiched between one end of the cylindrical member and the stepped surface; a valve-seat-forming portion that closes the cylindrical portion opposite to the pressurization chamber; a discharge valve seat formed on the wall surface of the valve-seat-forming portion opposite to the cylindrical portion; and a discharge valve passage connecting the discharge valve seat and the wall surface of the valve-seat-forming portion.

When unseated from the discharge valve seat or seated on the discharge valve seat, the discharge valve member is capable of opening or closing the discharge valve passage. The discharge valve biasing portion biases the discharge valve member to be closed.

In the valve body, the flange portion is sandwiched between the stepped surface of the housing and one end of the cylindrical member. The valve body is held in the housing with axial force exerted on the flange portion from the stepped surface of the housing and the cylindrical member. As a result, the movement of the valve body relative to the housing in the axial direction is restricted. For this reason, the discharge pressure of the high-pressure pump can be stabilized.

An exertion of force in the inward radial direction on the valve body is suppressed. Therefore, the exertion of force in the inward radial direction on the valve-seat-forming portion of the valve body is restricted. A deformation of the valve-seat-forming portion is restricted. This makes it possible to maintain the tight abutment between the discharge valve seat and the discharge valve member. It is possible to further stabilize the discharge pressure of the high-pressure pump.

According to another aspect of the invention, a high-pressure pump includes a plunger, a cylinder, a housing, a cylindrical member, a valve body, a discharge valve member, a holder, and a discharge valve biasing portion.

The cylinder includes: a plunger accommodating hole for reciprocatively accommodating the plunger; a pressurization chamber formed by its inner wall and the outer wall of one end of the plunger; a suction port for suctioning a fluid into the pressurization chamber; and a discharge port for discharging fluid pressurized in the pressurization chamber.

The housing includes an inner wall surface forming a discharge passage communicating with the discharge port. The cylindrical member is so provided that one end thereof is positioned inside the inner wall surface of the housing and includes a first stepped surface formed between both ends.

The valve body includes: a cylindrical portion housed inside of the cylindrical member; a first valve-seat-forming portion closing the end of the cylindrical portion opposite to the pressurization chamber; a second valve-seat-forming portion protruded from the first valve-seat-forming portion opposite to the cylindrical portion; a second stepped surface formed outside the second valve-seat-forming portion; a discharge valve seat formed on the wall surface of the second valve-seat-forming portion opposite to the first valve-seat-forming portion; and a discharge valve passage connecting the discharge valve seat and the wall surface of the first valve-seat-forming portion.

When unseated from the discharge valve seat or seated on the discharge valve seat, the discharge valve member is capable of opening or closing the discharge valve passage.

The holder includes: a holder cylindrical portion having the second valve-seat-forming portion of the valve body; a holder bottom portion closing the holder cylindrical portion; a holder flange portion extended from the holder cylindrical portion in the outward radial direction and being sandwiched between the first stepped surface and the second stepped surface of the valve body; and a through hole formed in at least one of the holder cylindrical portion and the holder bottom portion. The discharge valve biasing member is provided between the discharge valve member and the holder bottom portion to bias the discharge valve member to be closed. That is, the discharge valve biasing member is held by the holder.

The holder is provided inside of the cylindrical member in such a manner that its holder flange portion is sandwiched between the first stepped surface of the cylindrical member and the second stepped surface of the valve body. The holder is held with axial force exerted on the holder flange portion from the first stepped surface and the second stepped surface. As a result, the movement of the holder relative to the cylindrical member in the axial direction is restricted.

An exertion of force in the inward radial direction on the holder is suppressed. Therefore, the exertion of force in the inward radial direction from the inner wall of the holder on the second valve-seat-forming portion is suppressed. A deformation of the second valve seat formation portion is suppressed. This makes it possible to maintain the tight abutment between the discharge valve seat and the discharge valve member. As a result, it is possible to stabilize the discharge pressure of the high-pressure pump.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present disclosure will become more apparent from the following detailed description made with reference to the accompanying drawings. In the drawings:

FIG. **1** is a schematic sectional view of a high-pressure pump in a first embodiment of the invention;

FIG. **2** is a sectional view taken along a line II-II of FIG. **1**;

FIG. **3** is a sectional view taken along a line of FIG. **1**;

FIG. **4** is a sectional view of the cover of a high-pressure pump in the first embodiment of the invention;

FIG. **5**A is a sectional view of the cover of the high-pressure pump taken along a line Va-Va of FIG. **4**;

FIG. **5**B is a sectional view of the cover of the high-pressure pump taken along a line Vb-Vb of FIG. **4**;

FIG. **5**C is a sectional view of the cover of the high-pressure pump taken along a line Vc-Vc of FIG. **4**;

FIG. **6** is a sectional view taken along line VI-VI of FIG. **1**;

FIG. **7**A is an enlarged sectional view of the fuel-discharge-relief-portion of the high-pressure pump indicated by line Vila of FIG. **1**;

FIG. **7**B is an enlarged sectional view of the fuel-discharge-relief-portion of the high-pressure pump indicated by line VIIb of FIG. **3**;

FIG. **8** is a sectional view of the fuel-discharge-relief-portion of a high-pressure pump in a second embodiment of the invention;

FIG. **9** is a sectional view of the fuel-discharge-relief-portion of a high-pressure pump in a third embodiment of the invention;

FIG. **10** is a sectional view of the fuel-discharge-relief-portion of a high-pressure pump in a fourth embodiment of the invention;

FIG. **11** is a sectional view illustrating a high-pressure pump in a fifth embodiment of the invention;

FIG. **12** is a sectional view taken along a line XII-XII of FIG. **11**;

FIG. **13** is a sectional view taken along a line XIII-XIII of FIG. **11**;

FIG. **14**A is a sectional view illustrating a vicinity of the valve body of a high-pressure pump; and

FIG. **14**B is a sectional view illustrating a vicinity of the valve body of a high-pressure pump.

DETAILED DESCRIPTION

Hereafter, description will be given to multiple embodiments of the invention with reference to the drawings. In the drawings related to these embodiments, substantially identical constituent parts will be marked with identical reference numerals and the description thereof will be omitted.

[First Embodiment]

FIG. **1** to FIG. **7**B illustrate a high-pressure pump **1** according to a first embodiment of the invention. The high-pressure pump **1** supplies fuel pumped up from a fuel tank (not shown) by a low-pressure pump (not shown) to a pressurization chamber **14**. Then, the fuel pressurized in the pressurization chamber **14** is supplied from a discharge valve **93** to a fuel accumulator (not shown). The fuel accumulator is connected to a fuel injector. In the following description, the upper side of FIG. **1** will be taken as "up, upward or upper," and the low side of the FIG. **1** will be taken as "down, downward or lower."

The high-pressure pump **1** includes a body portion, a fuel supply portion **30**, a plunger portion **50**, a fuel suction portion **70**, and a fuel discharge relief portion **90**. The body portion includes a lower housing **11**, a cylinder **13** and an upper housing **15**.

The lower housing **11** includes: a cylindrical cylinder-holding-portion **111**; an annular plate-like engine-mounting-portion **112** protruded from the lower part of the cylinder holding portion **111** in the outward radial direction; and a cylindrical fitting portion **113** protruded from the engine-mounting-portion **112** in an opposite direction relative to the cylinder-holding-portion **111**.

In the engine-mounting-portion **112**, fuel passages **114** are formed in such a manner as to penetrate the engine-mounting-portion **112**. In this embodiment, two fuel passages **114** are provided at equal intervals in the circumferential direction. The outer wall of the fitting portion **113** is provided with an O-ring groove **115**. An O-ring is fit in this O-ring groove **115** for liquid-tightly sealing the gap formed between the fitting portion **113** and the engine.

The cylinder **13** is in the shape of a closed-end cylinder and is open toward the engine-mounting-portion **112** relative to the cylinder-holding-portion **111**. The outside wall **132***a* of its cylindrical portion **132** that slidably holds the plunger **51** is fixed on an inner wall **111***b* of the cylinder-holding-portion **111**. The cylinder **13** has an annular protrusion **135** that is protruded from the outside wall **132***a* of the cylindrical portion **132** in the outward radial direction. The top surface of the annular protrusion **135** is abutted against the bottom surface of the cylinder-holding-portion **111**. That is, the annular protrusion **135** functions as a movement restricting portion that restricts an upward movement of the cylinder **13** in the axial direction.

The cylinder **13** has the pressurization chamber **14** which is defined by an upper end face **515** of the plunger **51** inserted from the opening **133**, an inside wall **132***b* of the cylinder **13**, and an inner bottom wall **131***b* of the bottom portion **131**. The pressurization chamber **14** is a chamber for pressurizing fuel. In this embodiment, the inside diameter of the pressurization chamber **14** is set to a value larger than the inside diameter of the cylinder **13**. The cylinder **13** has the following in the outside wall **132***a* of the cylindrical portion **132** on the bottom portion **131** side: a suction port **141** penetrating it from the pressurization chamber **14** toward the fuel suction portion **70**; and a discharge port **142** penetrating it from the pressurization chamber **14** toward the fuel discharge relief portion **90**. The suction port **141** and the discharge port **142** are so formed that their inside diameters are increased as it goes to the outward radial direction. The upper end face **515** corresponds to an "outer wall" of the present invention. The inside wall **132***b* corresponds to an "inner wall" of the present invention.

As illustrated in FIG. **3**, the upper housing **15** is substantially in the shape of a rectangular parallelepiped extending in a direction substantially orthogonal to an axis of the cylinder **13**. In the upper housing **15**, the cylinder **13** is press-inserted into a cylinder housing chamber **151** formed in the center thereof. The outside wall **132***a* of the cylindrical portion **132** of the cylinder **13** and the inner wall of the cylinder housing chamber **151** are joined together so that the fuel pressurized in the pressurization chamber **14** does not leak from therebetween.

The upper housing **15** includes: a stepped first suction passage **161** penetrating the upper housing **15** in longitudinal direction thereof toward the opposite side to the pressurization chamber **14** with respect to the suction port **141**; and multiple second suction passages **162** penetrating it from the first suction passage **161** toward the side wall of the upper housing **15**. The fuel suction portion **70** is press-inserted and fixed in the first suction passage **161**.

The upper housing **15** includes a stepped first discharge passage **163** penetrating the upper housing **15** in a longitudinal direction thereof toward the opposite side to the pressurization chamber **14** with respect to the discharge port **142**. The fuel-discharge-relief-portion **90** is press inserted and fixed in the first discharge passage **163**. The upper housing **15** corresponds to a "housing" of the present invention. The first discharge passage **163** corresponds to a "fuel passage" of the present invention.

The fuel supply portion **30** will be described hereinafter.

The fuel supply portion **30** includes a cover **31**, a pulsation damper **33**, and a fuel inlet **40**.

As illustrated in FIG. **2**, the cover **31** is cup-shaped and accommodates the upper housing **15** therein. As illustrated in FIG. **4**, the side wall of the cover **31** includes: a first side wall portion **321** connected with the peripheral edge of the bottom portion **311**; a third side wall portion **323** forming the side wall on the engine-mounting-portion **112**; and a second side wall portion **322** connecting the first side wall portion **321** and the third side wall portion **323**.

FIGS. **5**A to **5**C respectively illustrate the cross sections of the cover **31** along an axis of the cylinder **13**. The first side wall portion **321** (FIG. **5**A) and the third side wall portion **323** (FIG. **5**C) are substantially circular and the third side wall portion **323** is larger in inside diameter than the first side wall portion **321**. As illustrated in FIG. **5**B, the second side wall portion **322** is substantially octangular. The second side wall portion **322** includes a first through hole **322***a*. The fuel suction portion **70** is inserted into the first through hole **322***a*. The second side wall portion **322** includes a second through hole **322***b* located on the opposite side to the first through hole **322***a*. The fuel discharge relief portion **90** is inserted into the second through hole **322***b*. In the second side wall portion **322**, a third through hole **322***c* is formed in the second side wall portion **322**. The third through hole **322***c* is provided with the fuel inlet **40** for supplying fuel to a fuel gallery **32** formed in the cover **31**.

The cover **31** is joined to the engine-mounting-portion **112** by welding so that the gap between the end of the third side wall portion **323** and the engine-mounting-portion **112** is liquid-tightly sealed. The cover **31** is joined to an inlet valve body **72** and a fuel discharge relief housing **91** by welding so that the following are liquid-tightly sealed: the gap between the first through hole **322***a* and the fuel suction portion **70** inserted therein and the gap between the second through hole **322***b* and the fuel discharge relief portion **90** inserted therein.

As illustrated in FIG. **2** and FIG. **3**, the fuel gallery **32** is formed by the inner wall of the cover **31**, the upper wall of the engine-mounting-portion **112** and the outer wall of the upper housing **15**. The fuel gallery **32** communicates with the first suction passage **161** through the second suction passages **162**. As a result, the fuel gallery **32** can be connected with the pressurization chamber **14** through the second suction passages **162** and the first suction passage **161**. The pulsation damper **33** for reducing pulsation in the fuel pressure in the fuel gallery **32** is accommodated and fixed inside the bottom portion **311** of the cover **31**. The cover **31** functions as a housing member for the pulsation damper **33**.

The pulsation damper **33** is configured by joining together the peripheral edge portions of two diaphragms **34**, **35**. Gas at a predetermined pressure is sealed therein. When the two diaphragms **34**, **35** are elastically deformed according to change in the fuel pressure in the fuel gallery **32**, the pulsation damper **33** thereby reduces fuel pressure pulsation. As illustrated in FIG. **6**, fuel passages **331** are formed between the pulsation damper **33** and the cover **31**. The fuel flows into around the pulsation damper **33** through the fuel passages **331**.

The plunger portion **50** will be described hereinafter.

The plunger portion **50** includes a plunger **51**, an oil seal holder **52**, a spring seat **53**, a plunger spring **54**, and the like. The plunger **51** is placed in the cylinder **13** to form the pressurization chamber **14**. The plunger **51** is a solid cylindrical member which is reciprocatively moved in the cylinder **13** in the axial direction. In the plunger **51**, a large-diameter portion **511** relatively large in outside diameter and a small-diameter portion **512** relatively small in outside diameter are integrally formed. The large-diameter portion **511** formed in the pressurization chamber **14** slides on the inner wall of the cylinder **13**. The small-diameter portion **512** is inserted into the oil seal holder **52**.

The oil seal holder **52** is placed at an end of the cylinder **13** and includes: a base portion **521** positioned on the circumference of the small-diameter portion **512** of the plunger **51**; and a press-fit portion **522** press-inserted into the fitting portion **113** of the lower housing **11**.

The base portion **521** has a ring-shaped seal **523** therein. The seal **523** is comprised of a ring **523***a* located inside and an O-ring **523***b* located outside. The thickness of a fuel oil film around the small-diameter portion **512** of the plunger **51** is adjusted by the seal **523** and the leakage of fuel to the engine is suppressed.

The base portion **521** has an oil seal **525** at a tip thereof. The thickness of an oil film around the small-diameter portion **512** of the plunger **51** is controlled by the oil seal **525** and oil leakage is suppressed. The press-fit portion **522** is a portion cylindrically extending around the base portion **521**. The extending cylindrical portion has "U-shaped". A recessed portion **526** corresponding to the press-fit portion **522** is formed in the lower housing **11**. The oil seal holder **52** is press fit so that the press-fit portion **522** is press-inserted to the inner wall of the recessed portion **526**.

The spring seat **53** is provided at an end of the plunger **51**. The end of the plunger **51** is abutted against, for example, a tappet (not shown). The tappet has its outer surface abutted against a cam installed on a cam shaft and is reciprocatively moved in the axial direction according to the cam profile by the rotation of the cam shaft.

One end of the plunger spring **54** is engaged with the spring seat **53** and the other end thereof is engaged with the press-fit portion **522** of the oil seal holder **52**. As a result, the plunger spring **54** functions as a return spring for the plunger **51** and biases the plunger **51** so as to abut against the tappet.

With this configuration, the plunger **51** is reciprocatively moved according to the rotation of the cam shaft. As this time, the volumetric capacity of the pressurization chamber **14** is varied by the movement of the large-diameter portion **511** of the plunger **51**.

The fuel suction portion **70** will be described hereinafter.

The fuel suction portion **70** includes an inlet valve portion **71** and an electromagnetic driving unit **81**. The inlet valve portion **71** includes the inlet valve body **72**, a seat body **73**, an inlet valve member **74**, a first spring holder **75**, a first spring **76**, and the like. The inlet valve body **72** is joined to the upper housing **15** by, for example, press fitting in the first suction passage **161**. The inlet valve body **72** has a suction chamber **711** therein. The suction chamber **711** communicates with the fuel gallery **32** by way of a suction passage **712** and the second suction passages **162**. The cylindrical seat body **73** is placed in the suction chamber **711**. A valve seat **731** that can be abutted against the inlet valve member **74** is formed on the seat body **73**.

The inlet valve member **74** is placed close to the pressurization chamber **14** relative to the seat body **73**. In the inlet valve member **74**, the shank **741** of a needle **86** extending from the inlet valve member **74** is reciprocatively moved in the suction chamber **711**. When unseated from the valve seat **731**, the inlet valve member **74** fluidly connects the suction chamber **711** and the pressurization chamber **14**. When seated on the valve seat **731**, the inlet valve member **74** fluidly disconnects the suction chamber **711** and the pressurization chamber **14**.

The first spring holder **75** is fixed in the fuel suction portion **70**. The first spring holder **75** restricts the movement of the inlet valve member **74** in the valve opening direction (rightward in FIG. **1**). The first spring **76** is provided between the first spring holder **75** and the inlet valve member **74**. The first spring **76** biases the inlet valve member **74** in the valve closing direction (leftward in FIG. **1**).

The electromagnetic driving unit **81** includes a flange **82**, a fixed core **83**, a movable core **84**, and the like. The flange **82** radially extends around the inlet valve body **72**. A substantially cylindrical movable core chamber **85** is provided in the interior of the inlet valve body **72**. The cylindrical movable core **84** is accommodated in the movable core chamber **85** so that it can be reciprocatively moved in the axial direction. The needle **86** is connected to the movable core **84**. The needle **86** is supported by a second spring holder **852** fixed on the inner wall of the inlet valve body **72** so that it can be reciprocatively moved. One end of the needle **86** is fixed on the movable core **84** and its shank **741** can be abutted against the inlet valve member **74**. The second spring holder **852** includes a second spring **851**. One end of the second spring is abutted against the wall surface of the second spring holder **852** in the axial direction. The other end is abutted against the wall surface of the shank **741** on the opposite side to the pressurization chamber **14**. The second spring **851** biases the movable core **84** and the needle **86** in the valve opening direction with a force larger than a force with which the first spring **76** biases the inlet valve member **74** in the valve closing direction.

The fixed core **83** is provided on the opposite side to the inlet valve member **74** with respect to the movable core **84** in the inward radial direction of a coil **87**. A cylindrical member **88** formed of a nonmagnetic material is provided between the fixed core **83** and the inlet valve body **72**. The cylindrical member **88** suppresses short-circuiting of magnetic flux between the fixed core **83** and the inlet valve body **73** and increases the amount of magnetic flux flowing through the magnetic gap between the movable core **84** and the fixed core **83**.

A bobbin **871** formed of resin is provided around the fixed core **84**. The coil **87** is wound on the bobbin **871**. The coil **87** is covered with a cylindrical case **89** in the radial direction so as to form a magnetic circuit together with the flange **82**, the inlet valve body **72**, the movable core **84**, and the fixed core **83**. A connector **891** extends in the outward radial direction of the case **89**. When the coil **87** is energized through the terminal **892** of the connector **891**, the coil **87** generates a magnetic field.

When the coil **87** is not energized, the movable core **84** and the fixed core **83** are away from each other due to the elastic force of the second spring **851**. As a result, the needle **86** integrated with the movable core **84** is moved toward the pressurization chamber **14** and the end face of the needle **86** presses the inlet valve member **74**. The inlet valve member **74** is thereby opened.

When the coil **87** is energized, a magnetic flux is generated in the magnetic circuit formed of the inlet valve body **72**, the fixed core **83**, the movable core **84**, the flange **82**, and the case **89**. As a result, the movable core **84** is magnetically attracted toward the fixed core **83** against the elastic force of the second spring **851**. Consequently, the needle **86** relieves pressing force against the inlet valve member **74**.

With reference to FIGS. **7**A and **7**B, the fuel-discharge-relief-portion **90** will be described. FIG. **7**A is an enlarged sectional view of the fuel-discharge-relief-portion **90** shown in FIG. **1**. FIG. **7**B is an enlarged sectional view of the fuel-discharge-relief-portion **90** shown in FIG. **3**.

The fuel-discharge-relief-portion **90** includes a fuel-discharge-relief-housing **91**, a valve body **92**, a discharge valve **93**, a relief valve **95**, and the like. The fuel-discharge-relief-housing **91** is substantially cylindrical and accommodates the valve body **92**, discharge valve **93**, and relief valve **95** therein. The fuel-discharge-relief-housing **91** is press-inserted in the first discharge passage **163** formed in the upper housing **15**. A fuel inflow port **98** into which the fuel pressurized in the pressurization chamber **14** flows is formed in the fuel-discharge-relief-housing **91**. A fuel discharge port **99** is formed in the fuel-discharge-relief-housing **91**.

The valve body **92** is inserted and installed in the fuel-discharge-relief-housing **91**. The valve body **92** is substantially shaped as a closed-end cylinder and has a bottom portion **923** and an opening toward the pressurization chamber **14**. In the bottom portion **923** of the valve body **92**, a relief valve outlet **953** located on the central axis of the valve body **92** is formed in the end face **921**. Further, discharge valve inlets **931**, **932** are formed in equal positions in the circumferential direction around the central axis. In the bottom portion **923** of the valve body **92**, a discharge valve outlet **933** located on the central axis of the valve body **92** is formed in the end face **922**. Further, relief valve inlets **951**, **952** are formed in equal positions in the circumferential direction around the central axis. The end face **921** corresponds to an "end face confronting the pressurization chamber." The end face **922** corresponds to "end face opposing to the pressurization chamber".

The discharge valve inlets **931**, **932** and the discharge valve outlet **933** communicate with each other through a first discharge valve passage **935** and second discharge valve passages **936**, **937** formed in the bottom portion **923** of the valve body **92**. The first discharge valve passage **935** is formed in the direction substantially perpendicular to the central axis of the valve body **92**. The second discharge valve passages **936**, **937** are formed in the directions substantially parallel with the central axis of the valve body **92**. The first discharge valve passage **935** and the second discharge valve passages **936**, **937** are formed by drilling. The first discharge valve passage **935** and the second discharge valve passages **936**, **937** correspond to "discharge valve passages"

The relief valve outlet **953** and the relief valve inlets **951**, **952** communicate with each other through a first relief valve passage **955** and second relief valve passages **956**, **957** formed in the bottom portion **923** of the valve body **92**. The first relief valve passage **955** is formed in the direction substantially perpendicular to the central axis of the valve body **92**. The second relief valve passages **956**, **957** are formed in the directions substantially parallel with the central axis of the valve body **92**. The first relief valve passage **955** and the second relief valve passages **956**, **957** are formed by drilling. The first discharge valve passage **935** is located between the first relief valve passage **955** and the fuel discharge port **99**. The first discharge valve passage **935** and the first relief valve passage **955** are shifted in the direction of the circumference of the valve body **92** and formed in skew positions relative to each other. The first relief valve passage **955** and the second relief valve passages **956**, **957** correspond to "relief valve passages".

In the fuel-discharge-relief-housing **91**, the discharge valve **93** is disposed adjacent to the fuel discharge port **99**. The discharge valve **93** includes a discharge valve member **94**, a discharge valve spring **943**, and a discharge valve spring holder **945**.

The discharge valve member **94** is substantially a flat plate. The discharge valve member **94** is arranged in such a manner as to be in contact with the end face **922** of the valve body **92** where the discharge valve outlet **933** is formed. That is, the discharge valve outlet **933** functions as a discharge valve seat **947** for the discharge valve member **94**. One end of the discharge valve spring **943** is engaged with the discharge valve member **94**. The other end of the discharge valve spring **943** is engaged with the discharge valve spring holder **945** which is in contact with the inner wall of the fuel-discharge-relief-housing **91**. The discharge valve spring **943** has biasing force that biases the discharge valve member **94** in a direction from the fuel discharge port **99** to the pressurization chamber **14**. That is, the discharge valve spring **943** biases the discharge valve member **94** in a direction in which the discharge valve outlet **933** is closed. The discharge valve spring holder **945** is in the shape of a circular tube having "U"-shaped sections. Multiple openings are formed in the discharge valve spring holder **945** so that the following flow of fuel is not blocked: the flow of fuel from the pressurization chamber **14** to the fuel discharge port **99** or from the fuel discharge port **99** to the pressurization chamber **14**.

A first pressure force is exerted on the plane **941** of the discharge valve member **94**. The pressure force of fuel in the fuel discharge port **99** exerts on the plane **942** of the discharge valve member **94**. A discharge valve acting force is the resultant force of this force and the biasing force of the discharge valve spring **943**. When the first pressure force is less than or equal to the discharge valve acting force, in the discharge valve **93**, the discharge valve member **94** is seated on the discharge valve seat **947** and the valve is closed. When the first pressure force is greater than the discharge valve acting force, the discharge valve member **94** is unseated from the discharge valve seat **947** and the valve is opened. As a result, the fuel that flowed from the pressurization chamber **14** into the fuel-discharge-relief-portion **90** is discharged from the fuel discharge port **99** by way of the second discharge valve passages **936**, **937** and the first discharge valve passage **935**.

The relief valve **95** is arranged in the valve body **92**. The relief valve **95** includes a flat relief valve member **96**, a relief valve spring **963**, and a relief valve spring holder **965**.

The relief valve member **96** is arranged in such a manner as to be in contact with the end face **921** of the valve body **92** forming the relief valve outlet **953**. That is, the relief valve outlet **953** functions as a relief valve seat **967** for the relief valve member **96**. One end of the relief valve spring **963** is engaged with the relief valve member **96**. The other end of the relief valve spring **963** is engaged with the relief valve spring holder **965**. The relief valve spring **963** has a biasing force that biases the relief valve member **96** in a direction from the pressurization chamber **14** to the fuel discharge port **99**. That is, the relief valve spring **963** biases the relief valve member **96** in a direction in which the relief valve outlet **953** is closed. In the bottom portion and cylindrical portion of the relief valve spring holder **965**, multiple openings are formed. Through these openings, the fuel flows between the pressurization chamber **14** and the fuel discharge port **99**. The biasing force of the relief valve spring **963** is set larger than the biasing force of the discharge valve spring **943**. The relief valve member **96** is arranged in series with the discharge valve member **94** in a direction of the axis of the valve body **91**.

A third pressure force is exerted on the plane **961** of the relief valve member **96**. The pressure of fuel in the pressurization chamber **14** exerts on the plane **962** of the relief valve member **96**. A relief valve acting force is a resultant force of this force and the biasing force of the relief valve spring **963**. When the third pressure force is less than or equal to the relief valve acting force, the relief valve member **96** is seated on the relief valve seat **967** and the valve is closed. When the third pressure force is greater than the relief valve acting force, the relief valve member **96** is unseated from the relief valve seat **967** and the valve is opened. As a result, the fuel that flowed from the fuel discharge port **99** into the fuel-discharge-relief-portion **90** is returned to the pressurization chamber **14** by way of the second relief valve passages **956**, **957** and the first relief valve passage **955**.

[Operation]

An operation of the high-pressure pump **1** will be described hereinafter.

(I) Suction Stroke

When the plunger **51** is moved down from the top dead center to the bottom dead center by rotation of the cam shaft, the volumetric capacity of the pressurization chamber **14** is increased and the fuel is depressurized. The discharge valve member **94** of the discharge valve **93** is seated on the discharge valve seat **947** and closes the fuel discharge port **99**. At this time, since the coil **87** has not been energized, the movable core **85** and the needle **86** are moved toward the pressurization chamber **14** by the biasing force of the second spring **85**. The needle **86** biases the inlet valve member **74** toward the first spring holder **75** to maintain the valve closed state. The fuel is suctioned from the fuel gallery **32** into the pressurization chamber **14** by way of the second suction passage **162**, the suction passage **712**, the suction chamber **711**, the first suction passage **161**, and the suction port **141**.

(II) Metering Stroke

When the plunger **51** is moved up from the bottom dead center to the top dead center by rotation of the cam shaft, the volumetric capacity of the pressurization chamber **14** is reduced. The energization of the coil **87** is stopped until a predetermined time. The inlet valve member **74** is in the open state. Thus, the low-pressure fuel once suctioned into the pressurization chamber **14** is returned to the suction chamber **711** by way of the suction port **141** and the first suction passage **161**.

When the energization of the coil **87** is started at the predetermined time in the process of the plunger **51** ascending, a magnetic attractive force is generated between the fixed core **83** and the movable core **84**. When this magnetic attractive force becomes larger than the biasing force of the second spring **851**, the movable core **84** and the needle **86** are moved toward the fixed core **83** and the biasing force of the needle **86** against the inlet valve member **74** is canceled.

Then, the inlet valve member **74** moves away from the first spring holder **75** by the biasing force of the first spring **76** and the inlet valve member **74** moves toward the suction chamber **711**. As a result, the inlet valve member **74** is seated on the valve seat **731** formed in the seat body **73**.

(III) Pressurization Stroke

After the inlet valve member **74** is closed, the fuel pressure in the pressurization chamber **14** is increased with ascent of the plunger **51**. When the force exerted on the plane **941** of the discharge valve member **94** by the pressure of fuel in the pressurization chamber **14** becomes larger than the following resultant force, the discharge valve **93** is opened. The resultant force exerted on the plane **942** is a resultant of the pressure force of fuel in the fuel discharge port **99** and the biasing force of the discharge valve spring **943**. The pressurized fuel pressurized in the pressurization chamber **14** is discharged from the fuel discharge port **99**.

The energization of the coil **87** is stopped in the pressurization stroke. Since the force exerted on the inlet valve member **74** by the fuel pressure in the pressurization chamber **14** is larger than the energizing force of the second spring **851**, the inlet valve member **74** maintains the valve closed state.

As mentioned above, the high-pressure pump **1** repeats the suction stroke, metering stroke, and pressurization stroke. The suctioned fuel is pressurized and discharged into the fuel accumulator through the fuel discharge port **99**. The fuel accumulator accumulates the discharged fuel. The fuel accumulated in the fuel accumulator is injected through a fuel injector (not shown).

When the pressure of the fuel in the fuel accumulator is less than or equal to a predetermined value, the relief valve member **96** is seated on the relief valve seat **967** by the biasing force of the relief valve spring **963**. Therefore, the relief valve **95** is closed. However, the fuel pressure in the fuel accumulator may be increased due to a malfunction. When the force exerted on the plane **961** of the relief valve member **96** by the pressure of fuel in the fuel accumulator exceeds a specified value, the relief valve member **96** is moved toward the pressurization chamber **14** and the relief valve **95** is closed. The specified value corresponds to the sum of the force exerted on the plane **962** of the relief valve member **96** by the pressure of fuel in the pressurization chamber **14** and the biasing force of the relief valve spring **963**. As a result, the flow of fuel from the fuel discharge port **99** to the pressurization chamber **14** is permitted.

[Advantages]

Advantages of the above high-pressure pump **1** will be described hereinafter.

(I) The discharge valve **93** and the relief valve **95** are accommodated in one valve housing **91**. The valve members of the two valves are formed coaxially with the valve body **92** and arranged in series. This makes it possible to simplify the configuration of the discharge relief portion **90**.

(II) The discharge valve **93** and the relief valve **951** are formed by machining the valve body **92** in the discharge relief housing **91**. Therefore, it is possible to simplify the configurations of the discharge valve **93** and the relief valve **95**, whereby the physical size of the discharge relief portion **90** can be reduced. Also, its manufacturing cost can be reduced.

(III) Since the discharge valve **93** and the relief valve **95** are accommodated in the discharge relief housing **91** that forms one passage, it is possible to reduce the dead volume that does not contribute to pressurization of fuel. Therefore, the discharging efficiency of the high-pressure pump **1** can be enhanced.

(IV) The valve body **92** defines passages for the discharge valve **93** and the relief valve **95**. As a result, the discharge relief portion **90** of the high-pressure pump **1** configures a "sub-assembly" which is comprised of the valve body **92** connected with the discharge valve **93** and the relief valve **95** and the discharge relief housing **91** in which the valve body **92** is accommodated. With this configuration, the effects (i) to (iii) described below are obtained when the high-pressure pump **1** is manufactured.

- (i) Since the discharge relief valve unit can be produced in a sub-assembly line different from the main assembly line for the high-pressure pump **1**, a tact time can be shortened.
- (ii) When inspecting and adjusting the valve opening pressure of the relief valve **95**, the discharge relief housing **91** only has to be set on an inspection equipment. The inspection equipment can be reduced in size and simplified.
- (iii) When the relief valve opening pressure is not within the predetermined range due to an inspecting equipment, it is inevitable to discard the work piece as a defective. For this reason, with the configuration in which the valve opening pressure of the relief valve **95** is adjusted as for the entire housing, any defective must be discarded together with the housing. Meanwhile, when the discharge relief portion **91** is configured as a sub-assembly, any defective discharge relief portion only has to be discarded and the loss cost arising from discard can be significantly reduced.

(V) The discharge valve inlets **931**, **932** formed in the valve body **92** are arranged at equal intervals in the circumferential direction about a central axis of the valve body **92**. As a result, the fuel flowing in the first discharge valve passage **935** and the second discharge valve passages **936**, **937** can flow without being biased to a specific direction. Therefore, it is possible to prevent degradation in discharging efficiency caused by an inclined discharge valve member **94**.

The relief valve inlets **951**, **952** formed in the valve body **92** are arranged at equal intervals in the circumferential direction around the central axis of the valve body **92**. As a result, the fuel flowing in the first relief valve passage **955** and the second relief valve passages **956**, **957** can flow without being biased to a specific direction. Therefore, it is possible to prevent degradation in relief efficiency caused by an inclined relief valve member.

(VI) The discharge valve member **94** and the relief valve member **96** are in a flat shape. The discharge valve seat **947** and the relief valve seat **967** are also flat. This makes it possible to reduce the number of steps for grinding and/or polishing the discharge valve **93** and the relief valve **95**. Its manufacturing cost can be reduced.

(VII) The relief valve spring holder **965** that supports the relief valve spring **963** is press-inserted into the valve body **92**. By adjusting the press-insert depth, the length of the relief valve spring **963** disposed between the relief valve spring holder **965** and the relief valve member **96** can be suitably adjusted. Thus, the biasing force of the relief valve spring **963** and the valve opening pressure of the relief valve **95** can be adjusted.

[Second Embodiment]

Referring to FIG. **8**, a second embodiment will be described hereinafter. The second embodiment is different from the first embodiment in the shape of the valve body of a relief valve. The substantially same parts and the components as the first embodiment are indicated with the same reference numeral and the same description will not be reiterated.

The relief valve member **975** of the relief valve **97** is substantially in a spherical shape. The relief valve member **975** is supported by a substantially conical valve seat **978** arranged at one end of the relief valve spring **963**.

A fifth pressure force is exerted on the plane **971** of the relief valve member **975** by the pressure of fuel in the fuel discharge port **99**. The pressure of fuel in the pressurization chamber **14** exerts on the plane **972** of the relief valve member **975**. A relief valve acting force is the resultant force of this force and the biasing force of the relief valve spring **963**. When the fifth pressure force is smaller than or equal to the relief valve acting force, the relief valve member **975** is seated on the relief valve seat **967** and the valve is closed. Meanwhile, when the fifth pressure force is greater than the relief valve acting force, the relief valve member **975** is unseated from the relief valve seat **967** and the valve is opened. As a result, the fuel that flowed from the fuel discharge port **99** into the fuel-discharge-relief-portion **90** is returned to the pressurization chamber **14** by way of the second relief valve passages **956**, **957** and the first relief valve passage **955**.

[Third Embodiment]

Referring to FIG. **9**, a third embodiment will be described hereinafter. The third embodiment is partly different from the first embodiment in the shape of the fuel-discharge-relief-housing. The substantially same parts and the components as the first embodiment are indicated with the same reference numeral and the same description will not be reiterated.

In the third embodiment, the following diameters of the inside diameter of a fuel-discharge-relief-housing **91**A are different from each other. That is, the inside diameter **r1** through which the relief valve spring holder **965** is inserted in the valve body **92**; and the inside diameter **r2** in which the bottom portion **923** of the valve body **92** is fixed. More specifically, as illustrated in FIG. **9**, the inside diameter **r1** is larger than the inside diameter r**2**. At the inside diameter r**1** of the fuel-discharge-relief-housing **91**A, the press-fit portion **965***a* of the relief valve spring holder **965** is opposed to the outer wall of the valve body cylindrical portion **924** abutted against the valve body **92**. At the inside diameter r**2**, the bottom portion **923** of the valve body **92** is fixed.

When the relief valve spring housing **965** is press fit and fixed in the valve body **92**, the press-fit portion **965***a* of the relief valve spring housing **965** pushes and widens the valve body cylindrical portion **924** in a radially outward direction. When the dimensions of the fuel-discharge-relief-housing **91**A supporting the valve body **92** are varied, it is likely that the fuel-discharge-relief-housing **91**A can not be press-inserted into the upper housing **15**. According to the present embodiment, the inside diameter of the fuel-discharge-relief-housing **91**A is increased. This inside diameter of the fuel-discharge-relief-housing **91**A is opposed to the outer wall of the valve body cylindrical portion **924** against which the press-fit portion **965***a* is abutted. This makes it possible to prevent variation in the dimensions of the fuel-discharge-relief-housing **91**A caused by widening of the valve body cylindrical portion **924** in the radially outward direction.

[Fourth Embodiment]

Referring to FIG. **10**, a fourth embodiment will be described hereinafter. The fourth embodiment is partly different from the first embodiment in the shape of a valve body. The substantially same parts and the components as the first embodiment are indicated with the same reference numeral and the same description will not be reiterated.

In the fourth embodiment, as illustrated in FIG. **10**, a valve body **92**A is so formed that the outside diameter r**3** of the valve body cylindrical portion **924**A is smaller than the outside diameter r**4** of the bottom portion **923** of the valve body **92**A.

When the relief valve spring housing **965** is press fit and fixed in the valve body **92**A, the press-fit portion **965***a* of the relief valve spring housing **965** pushes and widens the valve body cylindrical portion **924**A in a radially outward direction. When the dimensions of the fuel-discharge-relief-housing **91** supporting the valve body **92**A are varied, it is likely that the fuel-discharge-relief-housing **91** can not be press-inserted into the upper housing **15**. According to the present embodiment, the outside diameter r**3** of the valve body cylindrical portion **924** of the valve body **92**A is smaller than the outside diameter r**4** of the bottom portion **923** of the valve body **92**A. This makes it possible to prevent variation in the dimensions of the fuel-discharge-relief-housing **91**A caused by widening of the valve body cylindrical portion **924** in the radially outward direction.

[Modifications]

In the above first embodiment, third embodiment, and fourth embodiment, each relief valve member is formed in a flat shape. In the above-mentioned second embodiment, the relief valve member is formed in a spherical shape. However, the shape of the relief valve member is not limited to those. It may be conical. The shape of each discharge valve member is not limited to flat and may be spherical or conical.

In the above-mentioned embodiments, two fuel passages are formed in the lower housing. However, the number of fuel passages is not limited to this and may be one or more than two.

[Fifth Embodiment]

FIGS. **11** to **14**B illustrate a high-pressure pump according to a fifth embodiment. The high-pressure pump **2001** is a fuel pump that supplies fuel to an internal combustion engine at high pressure. The fuel supplied to the engine by the high-pressure pump **2001** is, for example, gasoline. The high-pressure pump **2001** suctions the fuel from the fuel tank and discharges the fuel to the delivery pipe (not shown).

The high-pressure pump **2001** includes a plunger **2020**, a cylinder **2030**, a housing **2040**, a cylindrical member **2050**, a valve body **2060**, a discharge valve member **2071**, a relief valve member **2072**, a discharge valve biasing portion **2080**, a relief valve biasing portion **2090**, and the like.

The plunger **2020** is formed as a solid cylinder of metal, such as stainless steel. The plunger **2020** is comprised of a large-diameter portion **2021**, a small-diameter, portion **2022**, and a protruded portion **2023**. The small-diameter portion **2022** extends from one end of the large-diameter portion **2021** in the axial direction and its outside diameter is smaller than the outside diameter of the large-diameter portion **2021**. The protruded portion **2023** is so formed that it is protruded from the center of the other end of the large-diameter portion **2021** to the opposite side to the small-diameter portion **2022**. Its outside diameter is smaller than the outside diameter of the large-diameter portion **2021**.

The cylinder **2030** is formed as a closed-end cylinder of metal, such as stainless steel. The plunger **2020** is inserted to inside the cylinder **2030** from the protruded portion **2023**. The cylinder **2030** has a pressurization chamber **2031** formed of its inner wall and the outer wall of the protruded portion **2023** of the plunger **2020**.

The inner wall of the cylinder **2030** and the outer wall of the large-diameter portion **2021** of the plunger **2020** can be slid on each other. That is, the cylinder **2030** houses the plunger **2020** so that it can be reciprocatively moved in the axial direction. The inside of the cylinder **2030** corresponds to a "plunger housing hole". When the plunger **2020** is reciprocatively moved inside the cylinder **2030**, the volumetric capacity of the pressurization chamber **2031** is varied. The hardness of the cylinder **2030** is enhanced by heat treatment, such as quenching, in order to suppress seizure and wear due to sliding of the plunger **2020**.

The cylinder **2030** includes a suction port **2032** and a discharge port **2033** that allow the outside in the radial direction and the pressurization chamber **2031** to communicate with each other. The suction port **2032** and the discharge port **2033** are formed on a virtual straight line orthogonal to the axis of the cylinder **2030**. That is, the suction port **2032** is formed on the opposite side to the discharge port **2033**. The cylinder **2030** has an annular protrusion **2034** protruded from its outer wall in the radially outward direction.

The housing **2040** is made from stainless steel. The housing **2040** is comprised of an upper housing **2041** and a lower housing **2046**.

As illustrated in FIGS. **11 and 12**, the upper housing **2041** is formed substantially in the shape of a rectangular parallelepiped. The upper housing **2041** has a housing hole **2042** in its longitudinal direction. In addition, the upper housing **2041** includes a suction passage **2043** and a discharge passage **2044** that connect together the outer wall surface and the inner wall surface forming the housing hole **2042**. The discharge passage **2044** is comprised of a first discharge passage **2441** communicating with the housing hole **2042** and a second discharge passage **2442** communicating with the first discharge passage **2441**.

The upper housing **2041** includes: a cylindrical first inner wall surface **2451** forming the first discharge passage **2441**; and a cylindrical second inner wall surface **2452** forming the second discharge passage **2442**. The second inner wall surface **2452** is larger in diameter than the first inner wall surface **2451**. An inside thread groove **2453** is formed in the second inner wall surface **2452**. The upper housing **2041** includes an annular stepped surface **2454** formed between the first inner wall surface **2451** and the second inner wall surface **2452**. The stepped surface **2454** corresponds to a "stepped surface". The upper housing **2041** includes multiple through holes **2045** that connect together the outer wall surface and the inner wall surface forming the suction passage **2043**.

The lower housing **2046** is comprised of a cylinder-holding-portion **2047**, a plate portion **2048**, and a cylindrical portion **2049**. The cylinder-holding-portion **2047** is formed in the shape of a hollow cylinder. The plate portion **2048** is formed in such a manner as to extend from one end of the cylinder-holding-portion **2047** in the radially outward direction. The cylindrical portion **2049** is formed in such a manner as to substantially cylindrically extend from the plate portion **2048** to the opposite side relative to the cylinder-holding-portion **2047**. Multiple through holes **2481** penetrating the plate portion **2048** in the direction of plate thickness are formed between the cylinder-holding-portion **2047** and the cylindrical portion **2049**. As illustrated in FIG. **12**, mounting holes **2482** into which fastening members for mounting the high-pressure pump **2001** on the engine are inserted are formed in the plate portion **2048**.

The cylinder **2030** is press-inserted into the cylinder-holding-portion **2047** of the lower housing **2046** and the housing hole **2042** of the upper housing **2041**. The suction passage **2043** of the upper housing **2041** communicates with the suction port **2032** of the cylinder **2030**. The discharge passage **2044** of the upper housing **2041** communicates with the discharge port **2033** of the cylinder **2030**.

The annular protrusion **2034** of the cylinder **2030** is abutted against the lower housing **2046**. This restricts the movement of the cylinder **2030** relative to the lower housing **2046** and the upper housing **2041** in the axial direction. As mentioned above, the upper housing **2041** and the lower housing **2046** accommodate the cylinder **2030** so that the cylinder **2030** cannot make a relative movement.

In the present embodiment, a cover member **2011** is provided on the plate portion **2048** of the lower housing **2046**. The cover member **2011** is formed in the shape of a cup. The cover member **2011** is comprised of a substantially octagonal cylindrical portion **2111** and a bottom portion **2112** closing one end of the cylindrical portion **2111**. The cover member **2011** covers the upper housing **2041** and the cylinder-holding-portion **2047** of the lower housing **2046** so that they are positioned inside the cylindrical portion **2111**. The end of the cylindrical portion **2111** is abutted against the plate portion **2048** of the lower housing **2046** and circumferentially welded thereto. Thus, it is liquid-tightly sealed between the cylindrical portion **2111** and the plate portion **2048** and a fuel gallery **2113** is formed inside the cover member **2011**.

A hole **2121** is formed in the cylindrical portion **2111** in a position corresponding to the suction passage **2043**. A hole **2122** is formed in the cylindrical portion **2111** in a position corresponding to the discharge passage **2044**. As illustrated in FIG. **12**, a fuel inlet **2002** is attached to the cylindrical portion **2111**. The fuel inlet **2002** is formed in a cylindrical shape; and one end thereof is fit into a hole **2123** formed in the cylindrical portion **2111** and its circumference is welded to the cylindrical portion **2111**. A fuel pipe connected to the fuel tank, not shown, is connected to the other end of the fuel inlet **2002**. As a result, the fuel in the fuel tank is supplied to the fuel gallery **2113** by way of the fuel pipe and the fuel inlet **2002**. A filter **2003** is provided inside the other end of the fuel inlet **2002**.

A pulsation damper **2004** is provided between the bottom portion **2112** of the fuel gallery **2113** and the upper housing **2041**. The pulsation damper **2004** is formed by joining together the peripheral edge portions of two diaphragms and gas at a predetermined pressure is tightly sealed therein. The pulsation damper **2004** is held by a holding member **2005** fixed at a vicinity of the bottom portion **2112**. The pulsation damper **2004** is elastically deformed according to change in the fuel pressure in the fuel gallery **2113** and can thereby reduce fuel pressure pulsation.

An oil seal holder **2141** is provided at the end of the cylinder **2030**. The oil seal holder **2141** is comprised of a cylindrical base portion **2151** into which the small-diameter portion **2022** is inserted and a press-fit portion **2152** press-inserted into the cylindrical portion **2049** of the lower housing **2046**. The base portion **2151** and the press-fit portion **2152** are integrally formed. An annular seal **2142** is provided inside of the base portion **2151**. The seal **2142** is comprised of a ring located inside in the radial direction and a ring made of rubber located outside in the radial direction. The thickness of a fuel oil film around the small-diameter portion **2022** of the plunger **2020** is adjusted by the seal **2142** and the leakage of fuel to the engine is suppressed. An oil seal **2143** is provided at the other end of the base portion **2151**. The thickness of an oil film around the small-diameter portion **2022** of the plunger **2020** is adjusted by the oil seal **2143** and the leakage of oil is suppressed by the same.

The press-fit portion **2152** is comprised of: an inner cylindrical portion **2153** cylindrically extended from one end of the base portion **2151**; a connecting portion **2154** annularly extended from the end of the inner cylindrical portion **2153** on the opposite side to the base portion **2151** in the outward radial direction; and an outer cylindrical portion **2155** cylindrically extended from the outer edge of the connecting portion **2154** toward the base portion **2151**. As mentioned above, the press-fit portion **2152** is formed in a double cylindrical shape. The press-fit portion **2152** is press-inserted into the cylindrical portion **2049** so that the outer wall of the outer cylindrical portion **2155** is in contact with the inner wall of the cylindrical portion **2049** of the lower housing **2046**.

A disk-shaped spring seat **2144** is provided at the end of the small-diameter portion **2022** of the plunger **2020**. A spring **2145** is provided between the spring seat **2144** and the connecting portion **2154** of the press-fit portion **2152** of the oil seal holder **2141**.

When the high-pressure pump **2001** is mounted on the engine, the end of the small-diameter portion **2022** of the plunger **2020** is abutted against a tappet (not shown) of the engine. The tappet has its outer surface abutted against a cam installed on a cam shaft, and is reciprocatively moved in the axial direction according to the cam profile by the rotation of the cam shaft. One end of the spring **2145** is engaged with the spring seat **2144** and the other end thereof is anchored to the connecting portion **2154**. As a result, the spring **2145** functions as a return spring for the plunger **2020** and energizes the plunger **2020** so as to abut it against the tappet.

With the above configuration, the plunger **2020** is reciprocatively moved in the axial direction according to the rotation of the cam shaft. The volumetric capacity of the pressurization chamber **2031** is varied.

An inlet valve portion **2016** is provided in the suction passage **2043** of the upper housing **2041**. The inlet valve portion **2016** includes: an inlet valve body **2161**, a first cylindrical member **2162**, a second cylindrical member **2163**, a needle **2164**, an inlet valve member **2165**, a stopper **2166**, a first spring **2167**, a second spring **2168**, and the like.

The inlet valve body **2161** is formed in a substantially cylindrical shape and is so provided that the outer wall of one end thereof is abutted against the inner wall of the upper housing **2041** forming the suction passage **2043**. An annular inlet valve seat **2171** is formed on the end face of the inlet valve body **2161**. The inlet valve body **2161** includes multiple through holes **2172** that connect its inner wall and its outer wall.

The first cylindrical member **2162** is made from magnetic material. The first cylindrical member **2162** is inserted into the hole **2121** in the cylindrical portion **2111** of the cover member **2011**. Its outer wall is abutted against the inner wall of the upper housing **2041** forming the suction passage **2043**. The other end of the inlet valve body **2161** is positioned inside of the first cylindrical member **2162**.

The through holes **2045** in the upper housing **2041** and the through holes **2172** in the inlet valve body **2161** communicate with each other. As a result, the fuel gallery **2113** and the inside of the inlet valve body **2161** communicate with each other through the through holes **2045** and the through holes **2172**. The outer wall of the first cylindrical member **2162** and the rim of the hole **2121** in the cover member **2011** are welded together throughout the circumference. The liquid tightness of the fuel gallery **2113** is thereby maintained.

The second cylindrical member **2163** is formed in the shape of a closed-end cylinder. Its outer wall is abutted against the inner wall of the first cylindrical member **2162**. The needle **2164** is inserted into a hole formed in the bottom portion of the second cylindrical member **2163**. The needle **2164** has an annular protrusion **2173** protruded from the outer wall in the outward radial direction. The inlet valve member **2165** is formed in a disk shape and is provided in the inlet valve body **2161**.

The stopper **2166** is cup-shaped and is provided in such a manner as to confront the pressurization chamber **2031**. The inlet valve member **2165** is so provided that it can be reciprocatively moved in the axial direction between the inlet valve body **2161** and the stopper **2166**. Therefore, the inlet valve member **2165** can be abutted against the inlet valve seat **2171** of the inlet valve body **2161**. The inlet valve member **2165** can be abutted against the stopper **2166**. One end of the needle **2164** can be abutted against the center of the plane of the inlet valve member **2165** on one side.

The inlet valve member **2165** is unseated from the inlet valve seat **2171** of the inlet valve body **2161** or is seated on the inlet valve seat **2171**, whereby the suction passage **2043** is opened or closed.

The first spring **2167** is provided between the bottom portion of the second cylindrical member **2163** and the annular protrusion **173** of the needle **2164** to biases the needle **2164** toward the stopper **2166**. The second spring **2168** is provided between the bottom portion of the stopper **2166** and the inlet valve member **2165** to biases the inlet valve member **2165** toward the needle **2164**. In the present embodiment, the biasing force of the first spring **2167** is larger than that of the second spring **2168**. Without external force exerted on the needle **2164**, the inlet valve member **2165** is biased in the valve opening direction by the first spring **2167** and is pressed against the stopper **2166**. That is, at this time, the inlet valve member **2165** is opened.

An electromagnetic driving unit **2018** is provided in the inlet valve portion **2016**. The electromagnetic driving unit **2018** includes a movable core **2181**, a fixed core **2182**, a coil **2183**, and the like. The movable core **2181** is made from magnetic material and is press-inserted into the end of the needle **2164**. As a result, the movable core **2181** can be reciprocatively moved in the axial direction together with the needle **2164**.

The fixed core **2182** is made from magnetic material. A cylindrical member **2185** made from nonmagnetic material is provided between the fixed core **2182** and the first cylindrical member **2162**.

The coil **2183** is formed around the movable core **2181** and the fixed core **2182**. The coil **2183** is covered with a molded portion **2184** formed of a resin material. The molded portion **2184** includes a connector portion **2191** which protrudes from the outer wall in the outward radial direction. A terminal **2192** is insert-molded in the connector portion **2191**. The terminal **2192** and the coil **2183** are electrically connected with each other.

The molded portion **2184** is covered with a first cover member **2193** and a second cover member **2194**. The first cover member **2193** is formed in the shape of a closed-end cylinder and its bottom portion is abutted against the fixed core **2182**. The first cover member **2193** is made from magnetic material. The second cover member **2194** is a plate made from magnetic material and has a hole in the center thereof. The end of the first cylindrical member **2162** is inserted into this center hole. The second cover member **2194** and the first cylindrical member **2162** are abutted against each other. The second cover member **2194** is abutted against the end of the first cover member **2193**.

When the coil **2183** is energized through the terminal **2192**, it generates a magnetic field. When a magnetic field is generated in the coil **2183**, a magnetic circuit is formed in the fixed core **2182**, the first cover member **2193**, the second cover member **2194**, the first cylindrical member **2162**, and the movable core **2181**. The movable core **2181** is attracted toward the fixed core **2182** together with the needle **2164**. This magnetic circuit is so formed that it goes around the cylindrical member **2185** which is made from nonmagnetic material.

When the coil **2183** is not energized, the inlet valve member **2165** is biased toward the pressurization chamber **2031** through the needle **2164** by the biasing force of the first spring **2167** and is abutted against the stopper **2166**. Since the inlet valve member **2165** is away from the inlet valve seat **2171** at this time, the flows of fuel in the suction passage **2043** and the suction port **2032** are permitted. Meanwhile, when the coil **2183** is energized and the movable core **2181** and the needle **2164** are attracted toward the fixed core **2182**, the inlet valve member **2165** is biased to the inlet valve seat **2171** by the biasing force of the second spring **2168**. As a result, the flows of fuel in the suction passage **2043** and the suction port **2032** are interrupted.

As mentioned above, the inlet valve portion **2016** can permit or interrupt the flows of fuel in the suction passage **2043** and the suction port **2032** by the actuation of the electromagnetic driving unit **2018**. In this embodiment, the electromagnetic driving unit **2018** and the inlet valve portion **2016** form a normally-open-valve mechanism.

With reference to FIGS. **14**A and **14**B, the cylindrical member **2050**, valve body **2060**, the discharge valve member **2071**, the relief valve member **2072**, the discharge valve energizing means **2080**, and the relief valve energizing means **2090** will be described in detail.

The cylindrical member **2050** is made from stainless steel. The cylindrical member **2050** is inserted into the hole **2122** in the cylindrical portion **2111** of the cover member **2011**. Its one end is positioned inside of the second inner wall surface **2452** of the upper housing **2041**. More specifically, an outside thread groove **2051** corresponding to the inside thread groove **2453** in the second inner wall surface **2452** is formed in the outer wall of one end of the cylindrical member **2050**. One end of the cylindrical member **2050** is screwed to inside of the second inner wall surface **2452**.

The cylindrical member **2050** has a stepped surface **2052** formed between one end and the other end thereof. The cylindrical member **2050** is formed in such a manner that the inside diameter of the extreme end is larger than those of the other portion. The stepped surface **2052** corresponds to a "first stepped surface."

A thread groove **2053** is formed in the outer wall of the cylindrical member **2050** and the fuel pipe connected to the delivery pipe is connected thereto. The outer wall of the cylindrical member **2050** and an inner periphery of the hole **2122** in the cover member **2011** are welded together. The liquid tightness of the fuel gallery **2113** is thereby maintained.

The valve body **2060** is formed of metal, such as stainless steel and includes a cylindrical portion **2061**, a flange portion **2062**, a first valve-seat-forming portion **2063**, a second valve-seat-forming portion **2064**, a stepped surface **2065**, a discharge valve seat **2066**, a relief valve seat **2067**, a discharge valve passage **2068**, a relief valve passage **2069**, and the like.

The cylindrical portion **2061** is accommodated in the cylindrical member **2050**. The cylindrical member **2050** is formed in such a manner that the inside diameter of the extreme end is larger than those of the other portions. Therefore, a part of the outer wall of the cylindrical portion **2061** is in contact with an inner wall surface of the cylindrical member **2050**. As a result, an annular clearance C**1** is formed between the outer wall of the cylindrical portion **2061** and the inner wall of the cylindrical member **2050**. In this embodiment, the outside diameter of the cylindrical portion **2061** is slightly larger than the inside diameter of the portion of the cylindrical member **2050**. For this reason, the cylindrical portion **2061** is lightly inserted into the cylindrical member **2050**.

The flange portion **2062** is annularly formed in such a manner as to extend from the end of the cylindrical portion **2061** in the outward radial direction. The flange portion **2062** is sandwiched between one end of the cylindrical member **2050** and the stepped surface **2454** of the upper housing **2041**. The one end of the cylindrical member **2050** is screwed to inside the second inner wall surface **2452** so that a contact pressure of a predetermined value is exerted on the area between the cylindrical member **2050** and the flange portion **2062** and the area between the flange portion **2062** and the stepped surface **2454**.

As illustrated in FIGS. **14**A and **14**B, the flange portion **2062** is formed in such a manner that its inner edge portion and its outer edge portion are tapered. The contacting area between the flange portion **2062** and the stepped surface **2454** is smaller than the maximum value of the sectional area of the flange portion **2062**. The cylindrical member **2050** is also formed in such a manner that its inner edge portion and its outer edge portion are tapered. The contacting area between the cylindrical member **2050** and the flange portion **2062** is smaller than the maximum value of the sectional area of the flange portion **2062**. Thereby, it possible to increase the contact pressure exerted on the area between the flange portion **2062** and the stepped surface **2454** and the area between the cylindrical member **2050** and the flange portion **2062**.

The first valve-seat-forming portion **2063** is formed in a shape of a solid cylinder. The portion **2063** closes the end of the cylindrical portion **2061**. The outside diameter of the first valve-seat-forming portion **2063** is set in such a manner that it is smaller than the outside diameter of the cylindrical portion **2061** and the inside diameter of the cylindrical member **2050**. For this reason, an annular clearance C**2** is formed between the outer wall of the first valve-seat-forming portion **2063** and the inner wall of the cylindrical member **2050**. This clearance C**2** corresponds to a "clearance" of the present invention.

The second valve-seat-forming portion **2064** is formed in such a manner as to protrude from the first valve-seat-forming portion **2063** in a direction apart from the cylindrical portion **2061**. The outside diameter of the second valve-seat-forming portion **2064** is smaller than the outside diameter of the first valve-seat-forming portion **2063**. As a result, an annular stepped surface **2065** is formed on the wall surface of the first valve seat formation portion **2063**. This stepped surface **2065** corresponds to a "second stepped surface." In this embodiment, the distance between the stepped surface **2065** and the stepped surface **2052** of the cylindrical member **2050** is set to a predetermined distance "d**1**".

The first valve-seat-forming portion **2063** and the second valve-seat-forming portion **2064** correspond to a "valve-seat-forming portion."

The discharge valve seat **2066** is formed on an end face of the second valve-seat-forming portion **2064**. The relief valve seat **2067** is formed on the end face of the first valve-seat-forming portion **2063**. The discharge valve seat **2066** and the relief valve seat **2067** are annularly formed.

The discharge valve passage **2068** is formed in the second valve-seat-forming portion **2064** and the first valve-seat-forming portion **2063** so that the discharge valve seat **2066** and the end face of the first valve-seat-forming portion **2063** are connected with each other. The relief valve passage **2069** is formed in the first valve-seat-forming portion **2063** so that the relief valve seat **2067** and the outer wall of the first valve-seat-forming portion **2063** are connected with each other. That is, the relief valve passage **2069** is formed so that its end opposite to the relief valve seat **2067** is connected to the clearance C**2**. The relief valve passage **2069** does not communicate with the discharge valve passage **2068**.

The discharge valve member **2071** is a disk made from stainless steel. The discharge valve member **2071** is arranged in such a manner as to abut against the discharge valve seat **2066**. The relief valve member **2072** is formed in a spherical shape. The relief valve member **2072** is so provided that it can be abutted against the relief valve seat **2067**.

The discharge valve biasing portion **2080** is comprised of a holder **2081** and a spring **2086**. The holder **2081** is formed by pressing sheet metal of stainless steel and is provided inside of the cylindrical member **2050**. The holder **2081** includes a holder cylindrical portion **2082**, a holder bottom portion **2083**, a holder flange portion **2084**, and through holes **2085**.

The holder cylindrical portion **2082** is so provided that the second valve-seat-forming portion **2064** is inserted into one end thereof. The inside diameter of the holder cylindrical portion **2082** and the outside diameter of the second valve seat formation portion **2064** are substantially identical with each other. Therefore, the holder cylindrical portion **2082** and the second valve seat formation portion **2064** are loosely fit together. The inside diameter of the holder cylindrical portion **2082** is slightly larger than the outside diameter of the discharge valve member **2071**. For this reason, the discharge valve member **2071** can be reciprocatively moved in the holder cylindrical portion **2082**. The holder bottom portion **2083** closes the other end of the holder cylindrical portion **2082**.

The holder flange portion **2084** is annularly formed so that it is extended from the one end of the holder cylindrical portion **2082** in the outward radial direction. The holder flange portion **2084** is sandwiched between the stepped-surface **2052** of the cylindrical member **2050** and the stepped surface **2065** of the first valve seat formation portion **2063**.

The holder flange portion **2084** is so set that its plate thickness is smaller than the distance "d1" between the stepped surface **2052** and the stepped surface **2065** and its outer edge portion is bent toward the stepped surface **2052**. For this reason, the holder flange portion **2084** can be elastically deformed between the stepped surface **2052** and the stepped surface **2065**. As a result, a force of a predetermined value is constantly exerted on the holder flange portion **2084** from the stepped surface **2052** and the stepped surface **2065**.

Multiple cutout grooves **2841** are formed in the outer edge portion of the holder flange portion **2084** in the circumferential direction. The relief valve passage **2069**, the clearance C**2** and an inner space of the cylindrical member **2050** communicate with each other through the cutout grooves **841**. One of the through holes **2085** is formed in the holder bottom portion **2083** and the others are formed in the holder cylindrical portion **2082** in the circumferential direction. The inside and outside of the holder **2081** communicate with each other through the holes **2085**.

The spring **2086** is provided between the discharge valve member **2071** and the holder bottom portion **2083**. The spring **2086** is a coil spring and one end thereof is engaged with the discharge valve member **2071** and the other end thereof is engaged with the holder bottom portion **2083**. As a result, the spring **2086** biases the discharge valve member **2071** to abut against the discharge valve seat **2066**. That is, the spring **2086** biases the discharge valve member **2071** in the seating direction. The spring **2086** corresponds to a "discharge valve biasing member."

The relief valve energizing means **2090** is comprised of a holder **2091**, a valve holding member **2095**, and a spring **2098**. The holder **2091** is formed in the shape of a closed-end cylinder of metal, such as stainless steel. The holder **2091** includes a holder cylindrical portion **2092**, a holder bottom portion **2093** and through holes **2094**. The holder bottom portion **2093** closes the end of the holder cylindrical portion **2092**. The holder **2091** is configured in such a manner that the outer wall of the holder cylindrical portion **2092** is fit or welded to the inner wall of the cylindrical portion **2061** of the valve body **2060**. One of the through holes **2094** is formed in the holder bottom portion **2093** and the others are formed in the holder cylindrical portion **2092** in the circumferential direction. The inside and outside of the holder **2091** communicate with each other through the through holes **2094**.

The valve holding member **2095** is comprised of an annular plate portion **2096** and a cylindrical portion **2097**. The cylindrical portion **2097** cylindrically extends from the inner edge end of the plate portion **2096** toward the pressurization chamber **2031**. The inner wall of the cylindrical portion **2097** is tapered so that its diameter is reduced toward the pressurization chamber **2031**. The relief valve member **2072** is held inside of the tapered inner wall of the cylindrical portion **2097**.

The spring **2098** is arranged between the valve holding member **2095** and the holder bottom portion **2093**. The spring **2098** is a coil spring. One end thereof is engaged with the valve holding member **2095** and the other end is engaged with the holder bottom portion **2093**. As a result, the spring **2098** biases the relief valve member **2072** through the valve holding member **2095** so as to abut against the relief valve seat **2067**. That is, the spring **2098** biases the relief valve member **2072** in the seating direction.

As mentioned above, the cylindrical member **2050** and the valve body **2060** are kept joined with each other. The valve body **2060** and the holder **2091** are kept joined with each other by fitting or welding. With this configuration, these members can be configured as a sub-assembly by assembling the cylindrical member **2050**, the valve body **2060**, the discharge valve member **2071**, the relief valve member **2072**, the discharge valve biasing portion **2080**, and the relief valve biasing portion **2090**. Therefore, the assembly of the high-pressure pump **2001** can be facilitated.

An operation of the high-pressure pump **2001** will be described hereinafter.

[Suction Stroke]

When the plunger **2020** is moved downward in FIG. **11**, the energization of the coil **2183** has been stopped. For this reason, the inlet valve member **2165** is biased toward the pressurization chamber **2031** by the needle **2164** receiving a force from the first spring **2167**. As a result, the inlet valve member **2165** is away from the inlet valve seat **2171** of the inlet valve body **2161**. When the plunger **2020** is moved downward in FIG. **11**, the pressure in the pressurization chamber **2031** is reduced. For this reason, the force which the inlet valve member **2165** receives from the fuel at the inlet valve seat **2171** is larger than the force which the inlet valve member **2165** receives from the fuel in the pressurization chamber **2031**. As a result, the force is applied to the inlet valve member **2165** in a direction away from the inlet valve seat **2171**. The inlet valve member **2165** is moved until it is abutted against the stopper **2166**. When the inlet valve member **2165** is away from the inlet valve seat **2171**, the fuel gallery **2113** communicates with the pressurization chamber **2031** through the through holes **2045**, the through holes **2172**, the inside of the inlet valve body **2161** and the suction port **2032**. Consequently, the fuel in the fuel gallery **2113** is suctioned into the pressurization chamber **2031** by way of the through holes **2045** and the through holes **2172** in this order.

[Metering Stroke]

When the plunger **2020** ascends from the bottom dead center toward the top dead center, a fuel pressure force is applied to the inlet valve member **2165** in a direction in which the inlet valve member **2165** is abutted against the inlet valve seat **2171**. However, when the coil **2183** is not energized, the needle **2164** is biased toward the inlet valve member **2165** by the biasing force of the first spring **2167**. For this reason, the movement of the inlet valve member **2165** toward the inlet valve seat **2171** is restricted by the needle **2164**. The inlet valve member **2165** is covered with the stopper **2166**. As a result, the flow of fuel discharged from the pressurization chamber **2031** to the fuel gallery **2113** does not directly collide with the inlet valve member **2165**. For this reason, the force applied to the inlet valve member **2165** in the valve closing direction is reduced.

In the metering stroke, the inlet valve member **2165** is kept away from the inlet valve seat **2171** while the energization of the coil **2183** is stopped. As a result, the fuel discharged from the pressurization chamber **2031** is returned to the fuel gallery **2113** by way of the through holes **2172** and the through holes **2045** in this order.

When the coil **2183** is energized in the metering stroke, a magnetic circuit is formed through the fixed core **2182**, the first cover member **2193**, the second cover member **2194**, the first cylindrical member **2162** and the movable core **2181**. As a result, magnetic attractive force is produced between the fixed core **2182** and the movable core **2181**. When the magnetic attractive force produced between the fixed core **2182** and the movable core **2181** becomes larger than the biasing force of the first spring **2167**, the movable core **2181** is moved toward the fixed core **2182**. For this reason, the needle **2164** integrated with the movable core **2181** is also moved toward the fixed core **2182**. When the needle **2164** is moved toward the fixed core **2182**, the inlet valve member **2165** and the needle **2164** are away from each other. The inlet valve member **2165** does not receive any forces from the needle **2164**. As a result, the inlet valve member **2165** is moved away from the stopper **2166** and moved toward the inlet valve seat **2171**. As a result, the inlet valve member **2165** is closed.

When the plunger **2020** ascends, the quantity of fuel returned from the pressurization chamber **2031** to the fuel gallery **2113** is adjusted by closing the suction passage **2043** between the pressurization chamber **2031** and the fuel gallery **2113**. As a result, the quantity of fuel pressurized in the pressurization chamber **2031** is determined. When the inlet valve member **2165** is moved toward the inlet valve seat **2171** and the inlet valve member **2165** is abutted against the inlet valve seat **2171**, the flow of fuel flowing in the suction passage **2043** is interrupted. This terminates the metering stroke of discharging fuel from the pressurization chamber **2031** to the fuel gallery **2113**.

[Pressurizing Stroke]

When the plunger **2020** further ascends toward the top dead center with the suction passage **2043** closed, the pressure of fuel in the pressurization chamber **2031** is increased. When the pressure of fuel in the pressurization chamber **2031** becomes higher than or equal to a predetermined value, the discharge valve member **2071** is moved away from the discharge valve seat **2066** against the biasing force of the spring **2086** and the fuel pressure force which the discharge valve member **2071** receives. As a result, the discharge valve member **2071** is opened and the fuel pressurized in the pressurization chamber **2031** is discharged from the high-pressure pump **2001** by way of the discharge valve passage **2068** and an inner space of the valve body **2060**. The fuel discharged from the high-pressure pump **2001** is supplied to the delivery pipe, (not shown).

When the pressure in the cylindrical member **2050** becomes higher than or equal to a predetermined value, the relief valve member **2072** is moved away from the relief valve seat **2067** against the biasing force of the spring **2098** and the fuel pressure force which the relief valve member **2072** receives. As a result, the relief valve member **2072** is opened. The fuel in the interior of the cylindrical member **2050** is returned to the pressurization chamber **2031** by way of the relief valve passage **2069**.

When the plunger **2020** is moved up to the top dead center, the energization of the coil **2183** is stopped and the inlet valve member **2165** is moved away from the inlet valve seat **2171** again. The plunger **2020** is moved downward in FIG. **11** again and the pressure of fuel in the pressurization chamber **2031** is reduced. As a result, the fuel is suctioned from the fuel gallery **2113** to the pressurization chamber **2031**.

When the inlet valve member **2165** is closed and the pressure of fuel in the pressurization chamber **2031** rises to the predetermined value, the energization of the coil **2183** may be stopped. When the pressure of fuel in the pressurization chamber **2031** rises, the fuel pressure force which the inlet valve member **2165** receives in an opening direction becomes larger than the force which the inlet valve member **2165** receives in a close direction. For this reason, even when the energization of the coil **2183** is stopped, the inlet valve member **2165** is kept abutted against the inlet valve seat **2171** by the force from the fuel in the pressurization chamber **2031**. The power consumption of the electromagnetic driving unit **2018** can be reduced by stopping the energization of the coil **2183** at a predetermined time point as mentioned above.

The high-pressure pump **2001** pressurizes and discharges suctioned fuel by repeating the above-mentioned “suction stroke,” “metering stroke,” and “pressurization stroke.” The fuel discharge rate is adjusted by controlling the timing of energization of the coil **2183** of the electromagnetic driving unit **2018**.

When the high-pressure pump **2001** is in operation, the pressure in the pressurization chamber **2031** is periodically changed. For this reason, a fuel pressure pulsation occurs in the fuel gallery **2113** communicating with the pressurization chamber **2031**. In this embodiment, this fuel pressure pulsation is suppressed by providing the fuel gallery **2113** with the pulsation damper **2004**.

In the pressurization stroke, the valve body **2060** receives fuel pressure from the pressurization chamber **2031**. When the pressure inside of the cylindrical member **2050** rises, the valve body **2060** receives a fuel pressure from the opposite side. When the high-pressure pump **2001** is in operation, as mentioned above, the fuel pressure force is repeatedly exerted on the valve body **2060** in the axial direction. In this embodiment, however, the valve body **2060** has the flange portion **2062** sandwiched between the stepped surface **2454** of the upper housing **2041** and one end of the cylindrical member **2050**. Therefore, the axial movement thereof relative to the upper housing **2041** is restricted.

In this embodiment, the valve body **2060** includes: the cylindrical portion **2061** housed inside of the cylindrical member **2050**; the flange portion **2062** extended from the cylindrical portion **2061** in the outward radial direction and sandwiched between the one end of the cylindrical member **2050** and the stepped surface **2454** of the housing **2040**; the first valve-seat-forming portion **2063** and second valve-seat-forming portion **2064** closing the end of the cylindrical portion **2061**; the discharge valve seat **2066** formed on the wall surface of the second valve-seat-forming portion **2064**; and the discharge valve passage **2068** that connects together the discharge valve seat **2066** and the wall surface of the first valve-seat-forming portion **2063**.

The discharge valve member **2071** is unseated from the discharge valve seat **2066** or seated on the discharge valve seat **2066** and can thereby open or close the discharge valve passage **2068**.

According to the above configuration, the valve body **2060** is configured in such a manner that the flange portion **2062** is sandwiched between the stepped surface **2454** of the housing **2040** and one end of the cylindrical member **2050**. The valve body **2060** is held in the housing **2040** with axial force exerted on its flange portion **2062** from the stepped surface **2454** of the housing **2040** and the one end of the cylindrical member **2050**. As a result, the axial movement of the valve body **2060** relative to the housing **2040** is restricted. The discharge pressure of the high-pressure pump **2001** can be stabilized.

It is restricted that a force is exerted on the valve body **2060** in the inward radial direction. It is restricted that a force is exerted on the first valve-seat-forming portion **2063** and second valve-seat-forming portion **2064** in the inward radial direction. Thus, it is restricted that the first valve-seat-forming portion **2063** and the second valve-seat-forming portion **2064** are deformed. Therefore, it is possible to maintain the tight abutment between the discharge valve seat **2066** and the discharge valve member **2071**. The discharge pressure of the high-pressure pump **2001** can be further stabilized.

In this embodiment, the housing **2040** has the inner wall surface that accommodates the cylinder **2030** and forms the discharge passage **2044** communicating with the discharge port **2033**. The cylindrical member **2050** is provided in such a manner as to be positioned inside of the above inner wall surface of the housing **2040**. It, has the stepped surface **2052** formed between the one end and the other end.

The valve body **2060** includes: the cylindrical portion **2061**; the first valve-seat-forming portion **2063**; the second valve-seat-forming portion **2064**; the stepped surface **2065** formed on the wall surface of the first valve-seat-forming portion **2063**; the discharge valve seat **2066**; and the discharge valve passage **2068** connecting the discharge valve seat **2066** and the wall surface of the first valve-seat-forming portion **2063**.

The discharge valve member **2071** is unseated from the discharge valve seat **2066** or seated on the discharge valve seat **2066** and can thereby open or close the discharge valve passage **2068**.

The holder **2081** includes: the holder cylindrical portion **2082** having the second valve-seat-forming portion **2064**; the holder bottom portion **2083**; and the holder flange portion **2084** extended from the holder cylindrical portion **2082**. The holder flange portion **2084** is sandwiched between the stepped surface **2052** of the cylindrical member **2050** and the stepped surface **2065** of the valve body **2060**. Further, the holder **2081** includes the through holes **2085** formed at least either of the holder cylindrical portion **2082** and the holder bottom portion **2083**.

The spring **2086** is arranged between the discharge valve member **2071** and the holder bottom portion **2083** to biases the discharge valve member **2071** in the seating direction. The spring **2086** is held by the holder **2081** and forms the discharge valve biasing portion **2080** together with the holder **2081**.

The holder **2081** is so provided that its holder flange portion **2084** is sandwiched between the stepped surface **2052** of the cylindrical member **2050** and the stepped surface **2065** of the valve body **2060** inside the cylindrical member **2050**. The holder **2081** is held with axial force exerted on its holder flange portion **2084** from the stepped surface **2052** and the stepped surface **2065**. The axial movement of the holder **2081** relative to the cylindrical member **2050** is restricted.

Also, it is restricted that the holder **2081** receives a force in the inward radial direction. Therefore, it is restricted that a force is exerted on the second valve-seat-forming portion **2064** from the inner wall of the holder **2081**. It is restricted that the second valve-seat-forming portion **2064** is deformed. Therefore, it is possible to maintain the tight abutment between the discharge valve seat **2066** and the discharge valve member **2071**. The discharge pressure of the high-pressure pump **2001** can be stabilized.

In this embodiment, the holder **2081** is formed by pressing sheet metal. For this reason, the holder **2081** can be easily manufactured. Therefore, it is possible to reduce the manufacturing cost of the high-pressure pump **2001**.

In this embodiment, the outer edge portion of the holder flange portion **2084** is bent toward the stepped surface **2052** of the cylindrical member **2050**. Thus, it can be elastically deformed between the stepped surface **2052** of the cylindrical member **2050** and the stepped surface **2065** of the valve body **2060**. As a result, even when the cylindrical member **2050** and/or the valve body **2060** is deformed by heat or pressure, a force of a predetermined value is constantly exerted on the holder flange portion **2084** of the holder **2081**. Therefore, it is restricted that the holder **2081** is worn away.

In this embodiment, the valve body **2060** includes the relief valve seat **2067** and the relief valve passage **2069**. The relief valve seat **2067** is formed on the wall surface of the first valve-seat-forming portion **2063**. The relief valve passage **2069** connects the relief valve seat **2067** and the wall surface of the first valve-seat-forming portion **2063**. The relief valve seat passage **2069** does not communicate with the discharge valve passage **2068**.

This embodiment further includes the relief valve member **2072** and the relief valve biasing portion **2090**. The relief valve member **2072** is unseated from the relief valve seat **2067** or seated on the relief valve seat **2067** to open or close the relief valve passage **2069**. The relief valve biasing portion **2090** biases the relief valve member **2072** in the seating direction. In this embodiment, it is restricted that a force is exerted on the second valve-seat-forming portion **2064** from the inner wall of the holder **2081**, whereby a deformation of the second valve-seat-forming portion **2064** is restricted. A deformation of the first valve-seat-forming portion **2063** connected to the second valve-seat-forming portion **2064** is also restricted.

Therefore, it is possible to maintain the tight abutment between the relief valve seat **2067** and the relief valve member **2072**. The relief pressure of the high-pressure pump **2001** can be stabilized.

In this embodiment, the annular clearance C**2** is formed between the outer wall of the first valve-seat-forming portion **2063** and the inner wall of the cylindrical member **2050**. For this reason, it can be avoided that a force is exerted on the first valve-seat-forming portion **2063** in the inward radial direction from the inner wall of the cylindrical member **2050**. This makes it possible to further suppress a deformation of the first valve seat formation portion **2063**. Therefore, it is possible to maintain the tight abutment between the relief valve seat **2067** and the relief valve member **2072**. As a result, the relief pressure of the high-pressure pump **2001** can be further stabilized.

In this embodiment, the exertion of force in the inward radial direction on the first valve-seat-forming portion **2063** is suppressed and thus the deformation of the first valve-seat-forming portion **2063** is suppressed. Therefore, it is possible to maintain the tight abutment between the relief valve seat **2067** and the relief valve member **2072**. The relief pressure of the high-pressure pump **2001** can be stabilized.

In this embodiment, the annular clearance C**2** is formed between the outer walls of the first valve-seat-forming portion **2063** and second valve-seat-forming portion **2064** and the inner wall of the cylindrical member **2050**. For this reason, it can be surely avoided that a force is exerted on the first valve-seat-forming portion **2063** and the second valve-seat-forming portion **2064** in the inward radial direction from the inner wall of the cylindrical member **2050**. It is possible to further suppress deformations of the first valve-seat-forming portion **2063** and the second valve-seat-forming portion **2064**.

In this embodiment, the relief valve passage **2069** is formed so that its end opposite to the relief valve seat **2067** is connected to the clearance C**2**. For this reason, the clearance C**2** can be used as part of the fuel flow path for discharging the fuel to the pressurization chamber **2031**. This makes it possible to shorten the passage length of the relief valve passage **2069** formed in the first valve-seat-forming portion **2063** and the second valve-seat-forming portion **2064**. Therefore, it is possible to reduce the volumetric capacity of the space (relief valve passage **2069**) formed in the first valve-seat-forming portion **2063** and the second valve-seat-forming portion **2064**. This makes it possible to enhance the strength of each of the first valve-seat-forming portion **2063** and the second valve-seat-forming portion **2064**.

At least one cutout groove **841** is formed in the outer edge portion of the holder flange portion **2084**. With this configuration, the clearance C**2** and the cutout grooves **841** can be used as part of the fuel flow path for discharging the fuel into the pressurization chamber **2031**. This makes it possible to shorten the passage length of the relief valve passage **2069** formed in the first valve-seat-forming portion **2063** and the second valve-seat-forming portion **2064**. Therefore, it is possible to reduce the volumetric capacity of the space (relief valve passage **2069**) formed in the first valve-seat-forming portion **2063** and the second valve-seat-forming portion **2064**. This makes it possible to enhance the strength of each of the first valve-seat-forming portion **2063** and the second valve-seat-forming portion **2064**.

In the present embodiment, the inner wall surface of the housing **2040** includes the first inner wall surface **2451** and the second inner wall surface **2452**. The housing **2040** has the stepped surface **2454** formed between the first inner wall surface **2451** and the second inner wall surface **2452**. The valve body **2060** is so provided that the end of the cylindrical portion **2061** is positioned in proximity to the stepped surface **2454**. As a result, even when the pressure is exerted on the valve body **2060**, the end of the cylindrical portion **2061** is engaged with the stepped surface **2454** so that the movement of the valve body **2060** toward the pressurization chamber **2031** is restricted. For this reason, the relief pressure of the high-pressure pump **2001** can be stabilized.

In the present embodiment, the valve body **2060** includes the flange portion **2062**. The flange portion **2062** extends from the end of the cylindrical portion **2061** in the outward radial direction in such a manner as to be sandwiched between one end of the cylindrical member **2050** and the stepped surface **2454** of the housing **2040**. The valve body **2060** is held in the housing **2040** with axial force exerted on the flange portion **2062**. As a result, the axial movement of the valve body **2060** relative to the housing **2040** is restricted. For this reason, the discharge pressure and relief pressure of the high-pressure pump **2001** can be stabilized.

The exertion of force in the inward radial direction on the valve body **2060** is suppressed. Thus a deformation of the valve body **2060** is suppressed. Therefore, it is possible to maintain the tight abutment between the discharge valve seat **2066** and the discharge valve member **2071** and between the relief valve seat **2067** and the relief valve member **2072**. It is possible to further stabilize the discharge pressure and relief pressure of the high-pressure pump **2001**.

In this embodiment, the inside thread groove **2453** is formed in the second inner wall surface **2452** of the housing **2040**. The cylindrical member **2050** has the outside thread groove **2051** corresponding to the inside thread groove **2453**. One end of the cylindrical member **2050** is screwed to inside of the second inner wall surface **2452**. This makes it possible to continuously exert an axial force on the flange portion **2062** of the valve body **2060** from the one end of the cylindrical member **2050**. Since the inside thread groove **2453** and the outside thread groove **2051** are engaged with each other, the cylindrical member **2050** does not moves out from the second inner wall surface **2452** of the housing **2040**. For this reason, the valve body **2060** is prevented from moving out from inside of the second inner wall surface **2452** by the cylindrical member **2050** even when the pressure on the valve body **2060** is increased and a pressure force is exerted on the valve body **2060**.

In this embodiment, the area of abutment between the flange portion **2062** and the stepped surface **2454** is smaller than the maximum value of the sectional area of the flange portion **2062**. This makes it possible to increase a contact pressure between the flange portion **2062** and the stepped surface **2454**. For this reason, it is liquid-tightly sealed between the valve body **2060** and the housing **2040**. A leakage of fuel can be suppressed and a reduction in discharge pressure can be suppressed.

In this embodiment, the contacting area between the cylindrical member **2050** and the flange portion **2062** is smaller than the maximum value of the sectional area of the flange portion **2062**. This makes it possible to increase a contact pressure between the cylindrical member **2050** and the flange portion **2062**. For this reason, it is liquid-tightly sealed between the cylindrical member **2050** and the valve body **2060**. A leakage of fuel can be suppressed and a reduction in discharge pressure can be suppressed.

[Other Embodiment]

In the above embodiments, the relief valve passage is connected to the clearance between the first valve-seat-forming portion and the inner wall of the cylindrical member. In another embodiment, the relief valve passage is not connected to the above clearance. The clearance may be not formed between the outer wall of the valve-seat-forming portion and the inner wall of the cylindrical member.

The holder of the discharge valve biasing portion may not have a holder flange portion. In this case, the holder is fixed on the valve body by joining the holder cylindrical portion to the outer wall of the second valve seat formation portion by welding. The valve body may not have a second valve-seat-forming portion. In this case, the discharge valve seat is formed in the first valve-seat-forming portion.

The inside thread groove and the outside thread groove may not be formed in the housing and the cylindrical member. The cylindrical member may be press-inserted into the second inner wall surface of the housing.

The inner edge portion and the outer edge portion of the flange portion may be not tapered. That is, the contacting area between the flange portion and the stepped surface of the housing may be larger than or equal to the value of the sectional area of the flange portion.

The inner edge portion and the outer edge portion of the cylindrical member may be not tapered. That is, the contacting area between the cylindrical member and the flange portion of the valve body may be approximately equal to the sectional area of the flange portion.

The valve body may not have a relief valve seat nor a relief valve passage. The relief valve member and the relief valve biasing portion may be not provided.

At least two of the cylinder, the upper housing, and the lower housing may be integrally formed. The cover member may be formed integrally with the upper housing or the lower housing.

The electromagnetic driving unit and the inlet valve portion may be configured as a normally-closed valve mechanism. In a case that the inlet valve portion is a normally-closed valve mechanism, the electromagnetic driving unit is not always necessary.

The pulsation damper may not be provided inside of the cover member. The cover member is not always necessary. In a case that no cover member is provided, the fuel may be directly supplied to the suction passage of the housing.

The holder that holds the discharge valve biasing member may be formed by casting or cutting a metal material. The outer edge portion of the holder flange portion of the holder may not be elastically bent.

The end of the relief valve passage may not be connected to the clearance. The relief valve passage may be formed on an end surface of the second valve forming portion opposite to the pressurization chamber. The clearance may not be formed between the outer wall of the first valve-seat-forming portion and the inner wall of the cylindrical member. Only one cutout groove may be formed in the holder flange portion. Alternatively, no cutout groove may be formed in the holder flange portion.

The valve body may not have a flange portion. In this configuration, it is desirable that the end of the cylindrical portion of the valve body should be abutted against the stepped surface between the first inner wall surface and second inner wall surface of the housing.

The high-pressure pump may be used as a fluid pump that discharges a fluid to a device other than an engine.

The invention is not limited to the above-mentioned embodiments and can be embodied in various modes without departing from the subject matter thereof.

What is claimed is:

1. A high-pressure pump comprising:

a plunger configured to perform a reciprocating movement;

a cylinder having a plunger accommodating hole for slidably accommodating the plunger, a pressurization chamber defined by an inner wall of the cylinder and an outer end wall of the plunger, a suction port configured to suction a fluid to the pressurization chamber, and a discharge port configured to discharge a fluid pressurized in the pressurization chamber;

a housing having a first inner wall surface that forms a first discharge passage that communicates with the discharge port, a second inner wall surface that forms a second discharge passage that communicates with the first discharge passage and being larger in inside diameter than the first inner wall surface, and a stepped surface formed between the first inner wall surface and the second inner wall surface;

a cylindrical member provided inside of the second inner wall surface;

a valve body having a cylindrical portion accommodated inside of the cylindrical member, a flange portion extended from an end of the cylindrical portion in an outward radial direction and sandwiched between one end of the cylindrical member and the stepped surface, a valve-seat-forming portion closing the end of the cylindrical portion opposite to the pressurization chamber, a discharge valve seat formed on the wall surface of the valve-seat-forming portion opposite to the cylindrical portion, and a discharge valve passage that connects the discharge valve seat and the wall surface of the valve-seat-forming portion;

a discharge valve member that is unseated from the discharge valve seat or seated on the discharge valve seat to open or close the discharge valve passage; and

a discharge valve biasing portion that biases the discharge valve member in a direction in which the discharge valve member is seated on the discharge valve seat.

2. A high-pressure pump according to claim **1**, wherein

the valve body includes a relief valve seat formed on the wall surface of the valve-seat-forming portion and a relief valve passage that connects the relief valve seat and the wall surface of the valve-seat-forming portion, and

the relief valve passage does not communicate with the discharge valve passage, the high-pressure pump further comprising:

a relief valve member that is unseated from the relief valve seat or seated on the relief valve seat to open or close the relief valve passage; and

a relief valve biasing portion that biases the relief valve member to be seated on the relief valve seat.

3. A high-pressure pump according to claim **2**, wherein an annular clearance is formed between the outer wall of the valve-seat-forming portion and the inner wall of the cylindrical member.

4. A high-pressure pump according to claim **2**, wherein the relief valve passage is configured in such a manner that its one end opposite to the relief valve seat is connected to the clearance.

5. A high-pressure pump according to claim **1**, wherein

an inside thread groove is formed in the second inner wall surface,

the cylindrical member has an outside thread groove that corresponds to the inside thread groove, and

the cylindrical member is screwed to inside of the second inner wall surface.

6. A high-pressure pump according to claim **1**, wherein a contacting area between the flange portion and the stepped surface is smaller than a maximum value of a sectional area of the flange portion in a plane perpendicular to an axis of the cylindrical portion.

7. A high-pressure pump according to claim **1**, wherein a contacting area between the cylindrical member and the flange portion is smaller than a maximum value of a sectional area of the flange portion in a plane perpendicular to an axis of the cylindrical portion.

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